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Volume XV, No. 3

PASTURE AND FODDER CROP RESEARCH IN THE TROPICS.

PLOT SIZE IN FIELD EXPERIMENTS WITH *COFFEA ARABICA*.

ENTOMOLOGICAL CONTRIBUTIONS TO THE STUDY OF THE SUGAR-CANE FROGHOPPER.

PRICE 6d.

R.C.W. 1925.

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## PASTURE AND FODDER CROP RESEARCH IN THE TROPICS.

### Its Agricultural Significance and Importance in Land Utilisation and Improvement.

THE Fourth International Grassland Congress, held at Aberystwyth last year, has stimulated the interest of the agricultural world in problems of pasture and fodder crop management. It is only within the last few decades that scientific research in this branch of crop husbandry has been started on any serious scale. The explanation of this hiatus in the agricultural research programme would appear to lie in the exceptional efficiency of artificial or natural pastures which, alone of all farm crops, are capable of yielding a rich harvest for prolonged periods without cultural care or proper management. This fact has been responsible for the tendency in the past to regard grass as a natural product, suitable as a ground cover for waste or infertile lands generally, but only of minor importance as a cultivated crop. This tendency has not been limited to laymen, but has also been shared in extensively by the farming community. Actually, the total area under grass is far in excess of that occupied by all the other agricultural crops together, and trade statistics show that, from the monetary viewpoint, grass is the world's most valuable single crop. For example, in Australia, 60 per cent. of the total annual exports is said to be derived from her grasslands, and in Brazil, the value of the animal products exceeds the total of all the principal crops. Research workers at Aberystwyth and elsewhere have effectively demonstrated that pasture investigations must not only embrace forage production but should also cover the wider field of farm management in general, and soil conservation and land utilisation in particular. The work is therefore in the nature of long range research, but already satisfactory progress has been achieved. The results to date indicate that there is considerable room for improvement in the existing systems of management applied to grasslands, improvement which would lead to a bigger yield of better quality herbage and a greatly increased stock-carrying capacity. Among the more revolutionary ideas is the project to reclaim large tracts of waste land or deteriorated hill pastures, which in the past have been regarded as national liabilities rather than assets. Apparently, this reclamation is not only technically possible, but can even be acnieved in a comparatively short space of time. Control of

the biotic factor, *i.e.*, the influence of the grazing animal on the sward, is now considered to be one of the key methods whereby pasture improvement schemes can most easily and cheaply be put into practice. The high nutritive quality of young grass is an established fact, and the manufacture of dried-grass concentrate meal has become a commercial proposition. The use of grass-drying machinery, along with a modified harvesting technique, is gradually gaining in popularity at the expense of the older process of haymaking by natural means. The new method provides an effective insurance against inclement weather and should lead to an improvement both in the quantity and the quality of the final roughage. These are merely a few examples of the progress being achieved in the temperate zone as a direct result of an intensive grassland research programme. Admittedly, this line of research is still at a very early stage of development, and the new ideas have yet to undergo the acid test of their practical efficacy on a commercial scale. There is no doubt, however, that a more accurate idea of the true position of herbage plants in the economy of the farm is surely being evolved, and is already producing considerable modification of existing farm practice.

While there is undoubtedly a gradual infiltration of these theories into tropical and subtropical regions, the present position there, particularly in the tropics proper, is very much more backward and less satisfactory. Among the native farmers—and they are responsible for the tillage of the bulk of the cultivated terrain—the general state of agriculture is still relatively primitive and backward. Everything appears to militate against rapid progress as measured by European standards. For example, the land tenure system, the illiteracy and indebtedness of the people, the religious and tribal customs, the shifting system of agriculture frequently practised, all represent serious obstacles to rapid agricultural evolution. With the exception of certain tsetse fly or otherwise unsuitable localities, livestock, mainly cattle, is plentiful. The stock is used indiscriminately for work, meat, or milk. The rations are of the poorest, consisting of crop residues, the ground herbage in forests, plantations, and waste land, and the meagre yield of overstocked communal grazings. The growing of fodder crops as such, and the proper cultivation of pasture land are considered unnecessary refinements. As soon as the population or the head of stock increases beyond the number that the land can comfortably carry and recuperate from during the intermittent rest periods of the agricultural cycle, soil exhaustion and erosion make their appearance and ultimately, large tracts of originally fertile land may have to be abandoned. In fairness to the native cultivator, it must be admitted that, in the past, the process has probably been accelerated through indiscriminate cultural exploitation by commercial enterprise. Whatever the cause, one of the major problems, that many tropical administrations have to contend with, is the conservation of soil resources and the prevention of erosion in the widest meaning of the term.

This brief explanation of certain aspects of tropical agriculture is really necessary to a reasonable understanding of the significance of grassland research. In the equatorial zone, the erosion menace is generally admitted to be more serious than in cooler climates, and in justice to posterity, the problem will have to be tackled in a comprehensive manner. Before any effective anti-erosion measures can be enforced, the causative agencies have to be tabulated, appropriate measures of prevention and cure evolved, and the best means of putting them into general practice determined. The erosion problem is intimately associated with the utilisation of soil resources by man, the clearing of virgin forest for cultivation, the systems of agriculture practised thereafter, overstocking and overcropping of the land, and the gradual and wasteful elimination of the natural agencies which in the past have not only prevented erosion but may also have produced a definite rise in the fertility status. The solution comes from the re-establishment—with particular reference to key localities such as watersheds—of a type of vegetative cover that will be an effective preventative. Research has shown that for this purpose, with the exception of virgin tropical forest, a thick permanent grass sward is *facile princeps*. To establish and maintain such a cover postulates a balanced system of agriculture in which the cropping and stocking is controlled so that the land suffers neither from any form of erosion, nor from excessive reduction in fertility through the realisation of its grazing value.

The opinion has been expressed by certain competent authorities that, in many parts of the tropics, this can best be achieved by the establishment of a system of mixed farming, including a thriving livestock industry organised on sound scientific principles. This would entail considerable modification of current ideas held by the indigenous population regarding the part played by livestock in the farming system. It would also necessitate a sound knowledge of pastures and pasture management, of the available fodder crops and grasses, and of their nutritive quality, stock carrying capacity, and cultural requirements. In the tropics, the available information in these directions is hopelessly inadequate, and although a certain amount of investigation is being undertaken at present, it only touches the fringe of the problem, and is often subordinated to other lines of research. The improvement of tropical stock has long been recognised as an important phase of agricultural progress. The full value of selection and breeding work with this end in view will only be achieved provided the stock rations are raised to a reasonable maintenance level. Improvement in the rations is dependent on better forage, and unless the latter can be arranged, the work of the livestock breeder will be largely nullified.

Enough has been said to show that herbage plant research in the tropics is bound to have a considerable influence on general agricultural progress. The large number of interacting factors requiring investigation, render this branch of research particularly intricate. Furthermore, the geographical region termed the tropics includes such a divergence of climates and soils, customs and peoples, that a separate experimental programme would almost certainly be required for each colony, and even for each large ecological zone within these colonies. Close co-ordination between the work undertaken at these various centres could be ensured by taking full advantage of the facilities offered by the Central Bureau for Herbage Plants, Aberystwyth. A free transfer both of new ideas and also of improved species of herbage plant as they become available, is essential to rapid progress.

The more primitive state of tropical life in general, and agriculture in particular, would necessitate the adoption of a rather different *modus operandi* in herbage research from that used in Europe. The biggest obstacle to progress is almost certain to be the essential inertia and conservatism of the agricultural community which forms the medium through which new ideas have to be put to practical advantage. Revolutionary changes in an agricultural system which represents the ingrained conviction of generations of farmers will have to be effected by making haste slowly. New ideas, however sound scientifically, will have to be presented in a form that can be gradually grafted on to the existing practice.

The obvious preliminary to any herbage research is an ecological survey of the area which it is desired to serve. Such a survey should attempt to include all the different soil and vegetal zones represented —forest, arable, plantation, waste, &c.—and particular account should be taken of areas devoted under the existing regime, to grazing or fodder production. From this survey, it should be possible to obtain some idea of the effect of the different methods of land utilisation on the soil fertility and on the ground cover. In localities where deterioration and erosion are occurring, some explanation of the reason should be formulated and suggestions for prevention promulgated. At the same time, a botanical classification of the local herbage plants should be made, and from observation, chemical analyses, and reference to the empirical knowledge of the local herdsmen, an estimate of their agricultural utility formed. A natural sequel to such a survey would be the taking over by Government of certain key localities for erosion control and the establishment of forest reserves or permanent pasturage let out for grazing on a controlled basis.

The next step would be the improvement of existing grazing areas, by the introduction and gradual establishment of better species of herbage plant and the eradication of poor types. This would entail a good deal of experimental work to determine the reactions of the vegetation in each area to different systems of management, and to ascertain the simplest method of altering the existing state of affairs for the better. The establishment of extensive artificial pasture is, as yet, out of the question, and in most cases, cultivation, even of the type that is being attempted in the improvement of hill pastures in the United Kingdom, would be impracticable. Results would have to be effected by inexpensive and simple measures that lie within the scope of the ordinary smallholder or can be superimposed on existing tribal practice. Such measures might include the limitation of stock to the carrying capacity of the land, simple systems of rotational grazing, the broadcasting of seed or other planting material of good species, the eradication of poisonous or otherwise undesirable herbs and shrubs, draining, and, possibly with Government assistance, manuring with suitable artificials. Recommendations would have to be supported by practical demonstrations to show the effects of the suggested technique in operation.

Concurrently, with this foundation work on a field scale, selection and breeding among indigenous herbage species should be undertaken by the plant breeder, and also the testing, in quarantine, of likely exotic varieties. Particular attention should be paid to the possibility of obtaining and introducing to the grazing areas a good perennial legume. Part of the proven inferiority of tropical pastures when compared with those in temperate climates can be attributed to the absence of a leguminous species in the sward. It has been said that "the most important agrostological problem in Australia consists in the search for some pasture legume", and the same might be stated with equal truth of almost any tropical colony.

In the insular tropics, and particularly where a dairying industry has become established, the soilage system of feeding stock tends to take the place of grazing the animals. On the soilage system, green herbage, cultivated or natural, is cut daily and fed in the fresh condition to the stock at the steading. This technique is particularly adapted to regions in which the even distribution of rainfall and temperature ensures a regular supply of fresh herbage throughout the year. In certain localities it may be advisable, in the more prolific months, to store the surplus roughage in one form or another against the drier seasons of the year. Using a cultivated perennial grass, yields of green herbage up to 100 tons per acre per annum are possible. Where the soilage system predominates, the type of agriculture borders on the intensive rather than the extensive, and the research would have to be organised on somewhat different lines to try and ascertain the fodder grass which, under cultivated or semi-cultivated conditions, yields the greatest nutritive value per acre. At the same time it would be necessary to work out the most suitable cutting rotation, the manures, if any, required to keep yields at a high level over long periods and any other relevant cultural details. The possibilities of dried grass production or other forms of

preservation in the tropics would subsequently have to be explored. In fact, the high yields and low labour rates of the tropics may bring the manufacture of dried grass for export within the bounds of possibility. At present, the low nutritive quality of the raw material, as compared with young pasture grass in England, is rather against this, but future research may discover a method of using tropical crops to make a dried grass concentrate of equivalent value to the British product.

In pasture and fodder crop research in the tropics, there is a rich and interesting field for the scientific investigator to explore, beginning with the search for new and better herbage crops and proceeding to the evolution of the best methods of utilising these in each ecological zone. As the ultimate objective, one might visualise the establisnment in the tropics of the ideal perennial pasture which would more than hold its own with the best that the temperate world can produce. The present lack of accurate scientific information regarding pasture and herbage crop problems would guarantee results of almost immediate practical significance. These would surely help to develop a sane and balanced agricultural policy, in which all the different methods of land utilisation would be correctly dove-tailed so as to ensure an appreciable rise in the fertility of cultivated land as a whole, and thereafter in rural prosperity.

D. D. P.

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# PLOT SIZE IN FIELD EXPERIMENTS WITH *COFFEA ARABICA*.

By S. M. GILBERT,

*Chief Scientific Officer, Coffee Research and Experiment Station, Lyamungu, Tanganyika Territory.*

## Introduction.

At the beginning of 1934, when the first steps were taken in opening up a research and experiment station for coffee in Tanganyika Territory, little or no work on field experiments had previously been attempted. Indeed, few experiments had been laid out anywhere on lines that permitted of an accurate analysis of variance by the methods evolved by Fisher (1).

In other perennial crops (2) (3) (4) (5) it had been demonstrated that the variation between individual trees was such that previous knowledge of the natural yields of the block to be studied was usually desirable and often essential to successful experimentation.

In existing coffee in Tanganyika Territory, as found on estates, it was readily seen that the population was very heterogeneous for age. It was suspected that this was also the case in regard to other factors.

Search for even blocks of coffee were not very successful and it was realized that the material available for experiments was likely to be difficult.

In view of this situation uniformity trials were commenced on a fairly large scale on 16 estates in 1934 and on an additional four in 1935. The blocks selected covered most of the conditions under which coffee is grown in this Territory.

## Objects.

Among the objects of this work was that of obtaining information as to suitable plot size for field experiments.

As a large number of experiments were necessary, owing to the widely varying conditions, the smaller the area needed for each experiment the better. For in that case more could be done by a limited staff and more planters would probably agree to handing over a relatively small area for experimentation.

## Method.

As far as possible blocks of coffee consisted of 700-800 contiguous trees which could take, if required later for a field experiment, a 4 by 4 Latin Square of 16 plots, each plot consisting of 20 trees, with provision for a single tree guard row round each plot.

Each tree was numbered and the harvest of cherry, at each picking, was recorded. The year's totals for each tree and plot were calculated. Results are available now for three consecutive years.

Two blocks, of approximately 800 trees, were selected from all the uniformity trials for study of plot size.

A 4 by 4 Latin Square was the method adopted for statistical analysis, no guard rows being reserved for this investigation. The same square was re-superimposed for each plot size at random on the yield plan. That is to say increase in plot size was not obtained by building up from the next smallest plot. Trees therefore fell in any one plot purely by chance. The same trees did appear in the same sized plot for the three successive years. The range of trees per plot which could be obtained by this means was from 6 to 36.

## Description of Blocks.

*Estate E* :

Variety of coffee : Blue Mountain—locall grown seed.
Planted in field : May 1932.
Planting distance : Slightly more than 9 feet by 9 feet square.
Shade : *Albizzia* sp.—young.
Soil : Red loam, volcanic.
Average annual rainfall about 36 inches.

**Table I.**

ESTATE "E".

| Trees per plot. | Year. | Mean per plot oz. | Plot Error % | Significant difference required. % |
|---|---|---|---|---|
| 6 | 1934 | 97 | 48.19 | 77.08 |
| | 1935 | 1,418 | 33.30 | 53.26 |
| | Mean of 1934-5 | 757 | 33.90 | 54.22 |
| | 1936 | 1,081 | 21.34 | 34.13 |
| | Mean of 1934-6 | 865 | 18.99 | 30.37 |
| 9 | 1934 | 174 | 35.23 | 56.35 |
| | 1935 | 2,128 | 20.84 | 33.33 |
| | Mean of 1934-5 | 1,151 | 21.45 | 34.31 |
| | 1936 | 1,185 | 23.24 | 37.17 |
| | Mean of 1934-6 | 1,162 | 20.07 | 32.09 |
| 12 | 1934 | 172 | 42.92 | 68.66 |
| | 1935 | 3,034 | 36.22 | 57.94 |
| | Mean of 1934-5 | 1,603 | 36.36 | 58.16 |
| | 1936 | 1,975 | 30.35 | 48.55 |
| | Mean of 1934-6 | 1,727 | 18.88 | 30.20 |
| 16 | 1934 | 320 | 37.48 | 59.94 |
| | 1935 | 3,835 | 29.23 | 46.76 |
| | Mean of 1934-5 | 2,077 | 29.76 | 47.60 |
| | 1936 | 2,348 | 21.89 | 35.02 |
| | Mean of 1934-6 | 2,168 | 21.45 | 34.31 |
| 20 | 1934 | 383 | 24.34 | 38.93 |
| | 1935 | 4,943 | 19.34 | 30.93 |
| | Mean of 1934-5 | 2,663 | 19.44 | 31.09 |
| | 1936 | 2,985 | 27.45 | 43.91 |
| | Mean of 1934-6 | 2,770 | 11.65 | 18.64 |
| 25 | 1934 | 457 | 22.32 | 35.70 |
| | 1935 | 6,075 | 17.86 | 28.57 |
| | Mean of 1934-5 | 3,266 | 17.82 | 28.50 |
| | 1936 | 3,632 | 24.05 | 38.48 |
| | Mean of 1934-6 | 3,388 | 12.12 | 19.37 |
| 30 | 1934 | 575 | 28.92 | 46.26 |
| | 1935 | 7,510 | 22.62 | 36.18 |
| | Mean of 1934-5 | 4,042 | 23.01 | 36.80 |
| | 1936 | 4,009 | 27.30 | 43.67 |
| | Mean of 1934-6 | 4,031 | 14.94 | 23.89 |
| 36 | 1934 | 646 | 26.24 | 41.98 |
| | 1935 | 9,181 | 20.95 | 33.51 |
| | Mean of 1934-5 | 4,913 | 21.19 | 33.90 |
| | 1936 | 5,186 | 23.30 | 37.27 |
| | Mean of 1934-6 | 5,004 | 10.28 | 16.44 |

**Table II.**

ESTATE "F".

| Trees per plot | Year | Mean per plot oz. | Plot Error % | Significant difference required. % |
|---|---|---|---|---|
| 6 | 1934 | 779 | 44.49 | 71.16 |
| | 1935 | 907 | 38.43 | 61.47 |
| | Mean of 1934-5 | 842 | 23.52 | 37.63 |
| | 1936 | 532 | 39.14 | 62.60 |
| 9 | 1934 | 1,038 | 52.96 | 84.71 |
| | 1935 | 1,476 | 27.65 | 44.22 |
| | Mean of 1934-5 | 956 | 22.71 | 70.02 |
| | 1936 | 1,257 | 43.78 | 36.32 |
| 12 | 1934 | 1,377 | 39.87 | 63.76 |
| | 1935 | 1,570 | 24.01 | 38.40 |
| | Mean of 1934-5 | 1,473 | 22.42 | 35.85 |
| | 1936 | 1,064 | 35.98 | 57.55 |
| 16 | 1934 | 2,083 | 28.09 | 44.94 |
| | 1935 | 2,300 | 25.63 | 41.00 |
| | Mean of 1934-5 | 2,191 | 10.78 | 17.24 |
| | 1936 | 1,348 | 32.96 | 52.71 |
| 20 | 1934 | 2,300 | 35.06 | 56.08 |
| | 1935 | 2,879 | 29.04 | 46.45 |
| | Mean of 1934-5 | 2,589 | 20.75 | 33.19 |
| | 1936 | 1,838 | 39.10 | 62.54 |
| 25 | 1934 | 2,904 | 28.37 | 45.38 |
| | 1935 | 3,489 | 30.35 | 48.55 |
| | Mean of 1934-5 | 3,196 | 23.10 | 36.94 |
| | 1936 | 2,665 | 32.77 | 52.41 |
| 30 | 1934 | 3,525 | 29.97 | 47.94 |
| | 1935 | 4,151 | 32.26 | 51.59 |
| | Mean of 1934-5 | 3,838 | 20.56 | 32.89 |
| | 1936 | 2,961 | 30.89 | 49.40 |
| 36 | 1934 | 4,294 | 25.57 | 37.70 |
| | 1935 | 4,543 | 36.38 | 58.19 |
| | Mean of 1934-5 | 4,418 | 18.41 | 31.04 |
| | 1936 | 3,745 | 27.18 | 43.47 |

*Estate F*:

Variety of coffee: Kents—seed imported from India.

Planted in field: 1927. Age in 1936—9 years.

Planting distance: 10 feet by 10 feet.

Shade: Irregular *Grevillia robusta*.

Soil: Red chocolate clay loam, volcanic.

Average annual rainfall about 37 inches.

**Results.**

Tables I and II set out respectively for Estates E and F summaries of the results obtained.

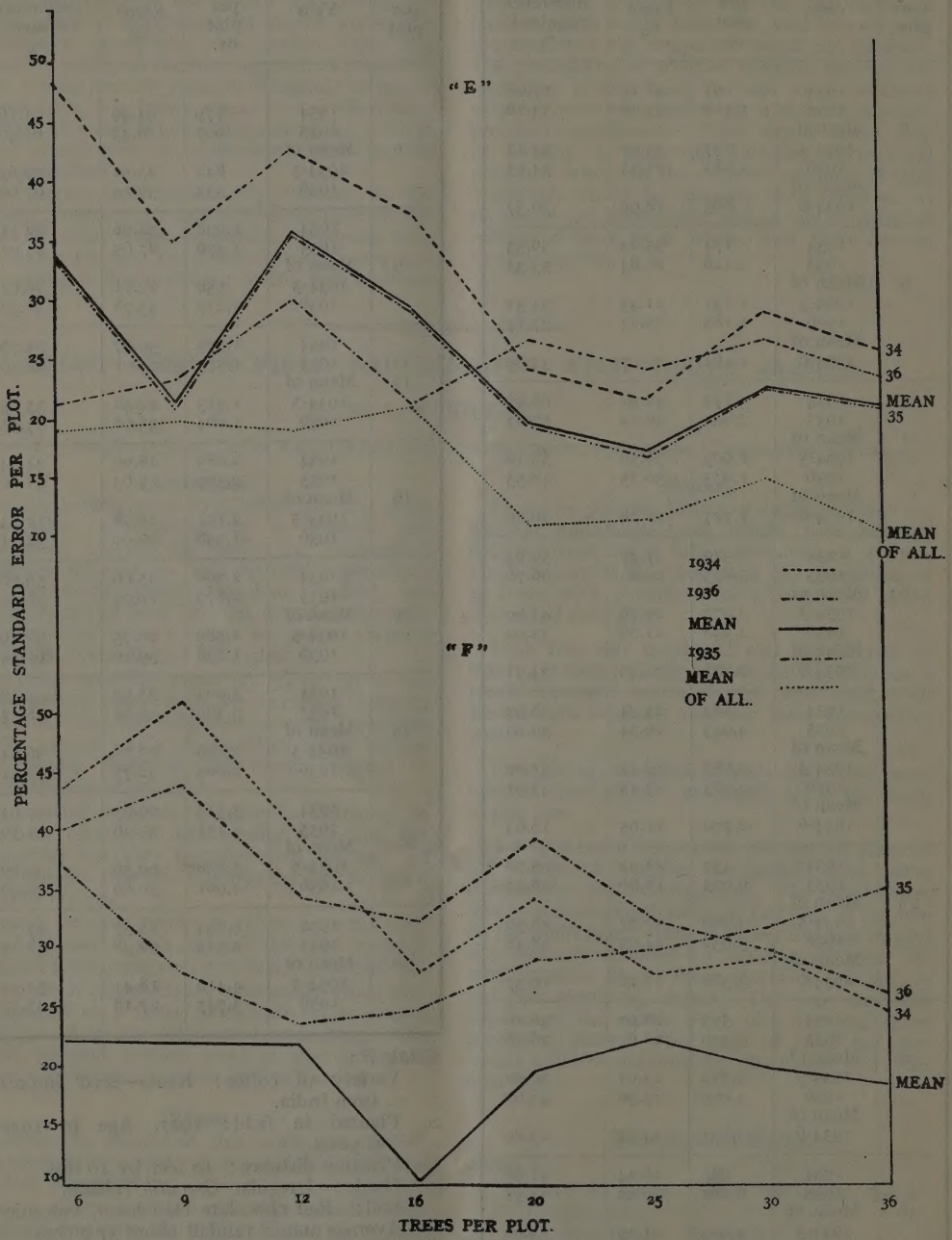
"E"
"F"
PERCENTAGE STANDARD ERROR PER PLOT.
TREES PER PLOT.
1934
1936
MEAN
1935
MEAN OF ALL.
34
36
MEAN
35
MEAN OF ALL.
35
36
34
MEAN
6
9
12
16
20
25
30
36
10
15
20
25
30
35
40
45
50

FIG. 1.

Fig. 1 gives this data in a form convenient for comparison of the effects on standard error per plot and on the significant differences required for varying plot size.

### Discussion.

(*a*) *Block E.*

This young Blue Mountain coffee produced a "fly" (first) crop in 1934. Many of the trees bore nothing. It is seen to be very unsuitable as a record of natural yield, being quite untypical.

In 1935 a crop set which was too great for the age of the trees. It would have been sound practice to have removed a large portion by "stripping".

In 1936 the trees yielded about an average crop for their age.

It is evident that the standard error per plot throughout is large as compared with other perennial crops (2) (3) (4) (5).

The combination of the yields of 1934 and 1935 has led to little gain in precision, for the curve of Standard Error follows almost exactly that of 1935, the heavy yielding year.

The more normal 1936 crop has a steadier curve. It is seen that plots of 16 trees and less fluctuate greatly and are quite unsuitable for experimentation.

Those of 20 trees and more have a much more even curve but an increase in number of trees per plot beyond 20 seems to give little advantage.

The difference required to make treatments significant, being of the order of 30 per cent. per plot, should be fairly readily obtainable on applying certain treatments in *Coffea arabica.* No treatments have been applied up to the end of 1936 so that natural yields for 3 years are available.

On combining three years natural yields the standard error is reduced for all plot sizes and the 20-tree plot appreciably so to 11.7 per cent. with the significant difference down to 18.6 per cent. This is a very decided increase in precision and natural yields for this period would appear desirable in young and irregular coffee.

(*b*) *Block F.*

This coffee, compared to that of the previous estate, bore relatively evenly. Biennial bearing was not so pronounced. In addition the coffee is older.

Treatments were applied in 1936 so that only the figures for 1934 and 1935 can be considered as to plot size.

A glance at Fig. 1 shows clearly the effect of combining two years yields. The standard error has dropped from the order of 30 to 40 per cent. down to about 22 per cent.

In this estate also plots of less than 16 trees are very erratic. The 16-tree plot, by chance, has been laid on an exceptionally even set of yielders and is not typical.

The curve for 20 trees per plot upwards is fairly horizontal and once again the above plot seems as suitable as any. Differences of 33 per cent. can be demonstrated.

(*c*) *General*:

It is worthy of note that the mean yield per plot for any size of plot in one year bears no direct relation to the standard error. This point has not yet been fully investigated.

In any given plot trees may be included which:

(1) always remain poor yielders due possibly to (*a*) genetic factors (*b*) age (*c*) environment,

(2) are very pronounced biennial bearers. Neighbouring trees are not always in step in this habit,

(3) under good conditions can respond to a considerably greater extent than their neighbours.

### Summary.

The paper describes the use of uniformity trials in determining suitable plot size for field experiments on *Coffea arabica.*

It is shown that under the conditions for the two estates examined 20 trees per plot appears a suitable size.

Three years natural yields are desirable in young and irregular coffee whilst two may suffice for older and more even blocks.

### Acknowledgments.

I am indebted to Mr. I. Thomson of the Station Staff for doing all the computations.

### Literature Cited.

(1) Fisher.—Statistical Methods for Research Workers.

(2) Coconuts.—*Tropical Agriculturist,* Volume LXXXIII, No. 1, 1934.

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(5) Rubber.—*Bulletin No.* 82.—*Department of Agriculture,* Ceylon.

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## OBITUARY.

### Sir Ambrose Thomas Stanton, K.C.M.G., M.D.

We much regret to announce the death on 25th January of Sir Ambrose Thomas Stanton who had represented the Colonial Office on the Governing Body of the Imperial College of Tropical Agriculture since 1928. At the time of his death Sir Thomas was Chief Medical Adviser to the Colonial Office, an appointment which he had held since 1926. Sir Thomas saw much service in the Federated Malay States where first, as Assistant to the Institute of Medical Research and later, as Director of the Government Laboratories he was responsible for some outstanding researches on certain tropical diseases. His published work includes a series of papers on the etiology and control of beri-beri; on the anopheles and other culicidae of Malaya, and on melioidosis.

# ENTOMOLOGICAL CONTRIBUTIONS TO THE STUDY OF THE SUGAR-CANE FROGHOPPER.

By Alan Pickles, M.Sc., A.I.C.T.A.

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## III.—Observations on the Biology of certain Neotropical Species of *Tomaspis* (Homoptera, Cercopidae).

In the course of the year 1933, the author commenced the present series of papers with two articles (11) dealing with the natural enemies of *Tomaspis saccharina* Dist. and with certain relations of cane field conditions to the attacks of this species. Publication of subsequent parts of the series has been considerably delayed by the author's absence on duty in Brazil during 1933-4 and by his subsequent transfer to the Department of Agriculture, in consequence of which, little opportunity has been found for the preparation of further contributions.

The present paper, the third article of the series, is in large measure a direct outcome of the work in Brazil, but the information here presented also includes the results of studies in Jamaica and in Trinidad, made under the auspices of the Sugar-Cane Investigation Committee. Such studies were conducted in the hope of discovering natural enemies of Cercopidae which could be employed in Trinidad in the control of the sugar-cane froghopper. Much of the Amazonian material was undescribed at the time these studies were made, but descriptions from contemporaneous collections made by Dr. J. G. Myers in the same localities have since appeared (1). A brief account of the ecology of these and of other neotropical froghoppers has been given by Myers (8), of part of which paper the present is in some respects an elaboration.

The Cercopidae form a well defined group of Auchenorhynchous Homoptera. Morphologically, they are characterised by the possession of two ocelli or none, of short, conical posterior coxae, of tibiae armed with one or two spines and a cluster of short apical spines and of antennae consisting of large, sub-pyriform bases and very slender setae. The nymphs of most genera secrete a froth, which is apparently a product of the Malpighian tubes from which bubbles are blown by the specially modified tip of the abdomen. It is to this froth or "spittle" that the popular names "froghoppers" and "cuckoo spit insects" refer.

The genus *Tomaspis* appears to require revision and the limits of the genus are variously regarded by different systematists. For present purposes, it would perhaps be most expedient to follow Stål (14) in referring Amyot and Serville's genera, *Tomaspis, Monecphora, Triecphora* and *Sphenorhina* to the one genus *Tomaspis,* which thus may be considered to include species from the New and Old World.

Our knowledge of the biology of the neotropical Cercopidae is very incomplete, but, as might be expected, it is least so in the case of *Tomaspis saccharina,* the most important economic species of the family.

### 1. Species associated with Forest Edges and Clearings.

(*a*) General.

In a discussion of the natural habitat of the sugar-cane froghopper, Withycombe (21) states that this froghopper originally came from the natural "grasslands" of Trinidad. Since a knowledge of the original habitat is important in elucidating the reasons for a pest insect's successful invasion of cultivations, a survey of various types of natural and semi-natural regions in Trinidad was undertaken by the author soon after the commencement of his studies. Grasslands in Trinidad comprise the natural savannahs and the swamp lands, the former occupying an extensive area bordering the southern slopes of the Northern Range Mountains (Fig. 1). Parts of the grassland region are cultivated, the swamp lands having been partly reclaimed for rice cultivation, for example, the Caroni Swamp which has been greatly altered from its original condition as a result of a reclamation scheme now abandoned. Large areas of savannah, however, are still in an unaltered condition. Four such savannahs may be recognised, separated from each other by tracts of forest and cultivated land. They are similar in general features, but each exhibits certain characteristic elements in its flora. They all approximate to the "orchard" type of savannah, having an open shrub stratum, consisting of various Malpighiaceous trees spaced at fairly regular intervals, with a grass carpet beneath and between them.

In general, the grass flora is highly characteristic, and includes grasses not usually found elsewhere. In the moister portions, however, and near the few roads and tracks which traverse the savannahs, other grasses intrude, some of which are known elsewhere to be froghopper hosts. The grasses which occur in such special areas include: *Andropogon bicornis, Paspalum densum* and *Paspalum virgatum.* Neither these nor the more typical savannah grasses have yet been found to harbour froghoppers.

In the shade of the forest intrusions, grasses of another type occur, notably *Paspalum conjugatum,* on which froghoppers may generally be found where shady conditions occur (c.f. Myers; 7).

The Caroni Swamp is divided by an artificial canal which separates the salt-affected land from land which receives only fresh water. The salty area is typical mangrove swamp, and its flora includes no grasses. The fresh water portion, however, supports in its higher parts, extensive beds of grass, chiefly *Panicum barbinode,* with occasional clumps of an introduced grass, *Panicum maximum,* and of *Paspalum densum* and *Paspalum*

*virgatum*. Certain wetter areas, particularly on the banks of the Caroni River, are inhabited by *Hymenachne amplexicaule*, with occasional stools of *Panicum grande*. In no case do these grasses bear a froghopper population.

Since the natural and semi-natural grasslands in Trinidad are never attacked by froghoppers, it is evident that they cannot constitute the natural habitat of these insects. Similar detailed examination of rain forest, on the other hand, shows that froghoppers of two species are usually to be found wherever the leafy canopy has been reduced sufficiently to permit the growth of suitable grasses. In general, the heavier forest soils more frequently support infested grass than the sandy soils (c.f. Urich; 16, p. 9). In the dense shade of tropical rain forest, grasses of any kind are rare, but they occur wherever shade is somewhat thinned through natural or artificial causes, such as the death of trees, erosion of the banks of streams, and land slides. Artificial clearings are created during the preparation of roads and tracks, in agricultural land-development, and during the processes of forest utilisation.

A particularly good example, showing the relation between the reduction of forest shade and the incidence of froghoppers, occurs between Moruga and Guayaguayare, where an oil pipe-line has been laid through the forest with the minimum of tree felling. Wherever the shade is slightly reduced, patches of *Paspalum conjugatum* occur, and the same grass also forms beds along certain of the river banks (10). These grass patches are affected all the year round by froghoppers of two species, namely, *T. saccharina* and *T. pubescens*. In a few places, mixed forest is replaced by Mora forest (a pure stand of *Dimorphandra mora*), in response to a change of soil from a stiff clay to coarse sand. In the shade of the Mora, grass patches are less common, but those which do occur are infested almost exclusively by *T. pubescens*, *T. saccharina* being much less common or entirely absent. Similar natural infestations of froghoppers of these two species also occur in thinner areas of the forests of the Northern Range, at elevations of about 2,000 feet (Morne Bleu), or even higher (summit of Mt. Tucuche). In the Nariva Swamp, *Tomaspis saccharina* occurs only at the edges of certain forest-clad islands rising out of the general level of the swamp.

Ample evidence is thus afforded to support the view that the froghoppers, *Tomaspis saccharina* and *T. pubescens*, are primitively associated in Trinidad with a forest habitat, and not with the natural open grasslands.

(*b*) *Tomaspis saccharina* DISTANT.

This species, which is recorded from the West Indian islands, Trinidad, Grenada and St. Vincent, has attracted considerable notice owing to its periodical devastations of the cane-fields of Trinidad. In Grenada, the economic importance of the insect is less, chiefly because the sugar industry there is of recent date as a capitalist undertaking. In St. Vincent, *T. saccharina* is only known from two specimens in the British Museum, collected by H. H. Smith towards the end of the last century. Metcalf and Bruner (5) state that *Monecphora flavifascia*, described by them from Cuba, is very similar to one form of *T. saccharina*, but it is very doubtful if it is really the same species.

In Trinidad, *Tomaspis saccharina* is almost exclusively a grass feeding species. Certain sedges are also attacked but not so generally. The hosts which the insect is known to attack include the following:—

| | |
|---|---|
| *Setaria barbata.* | *P. zizanioides.* |
| *S. sulcata.* | *Axonopus compressus.* |
| *Paspalum virgatum.* | *Anatherum zizanioides.* |
| *P. conjugatum.* | *Andropogon bicornis.* |
| *P. decumbens.* | *A. glomeratus.* |
| *Panicum laxum.* | *Cyperus diffusus.* |
| *P. polygonatum.* | *C. luzulae.* |
| *Panicum barbinode.* | *Scleria melaleuca.* |

It is noteworthy that the only species in this list that have affinities with the flora of natural open grassland are *Andropogon* spp. and *Panicum barbinode*. Of the other species, *Anatherum zizanioides* is an introduction, *Paspalum virgatum* has somewhat doubtful relations, while the remainder are associated with forest clearings and cocoa cultivations. Among cultivated plants, in addition to sugar-cane, maize and rice are also sometimes attacked by froghopper, though there are no records of serious infestations.

The natural enemies of the sugar-cane froghopper in its native habitat appear to be the same as those found attacking it in the cane fields, though there appears to be a difference in the relative abundance in the two cases. Several parasites of the eggs of *Tomaspis saccharina* are known of which, however, only one is of regular and widespread occurrence. The parasites recorded are: *Anagrus urichi* Pickles, *A. flaveolus* Waterhouse, *Oligosita giraulti* Crawford, *Paraphelinus tomaspidis* Howard and *Abbella tomaspidis* Pickles. Of these, the first is the most abundant, and under favourable conditions, destroys nearly 13 per cent. of the host eggs. The other parasites have not been found attacking froghopper eggs in the natural areas and even in the cane-fields, their occurrence is only occasional. *Anagrus flaveolus* is more generally known as a parasite of the eggs of *Peregrinus maidis* (18), and *Abbella tomaspidis* has also been bred from the eggs of an unknown Jassid.

Natural enemies of the nymphs include the predaceous larvae of a syrphid fly, *Salpingogaster nigra* Schiner, a number of spiders of the family Attidae, and various frogs, lizards and birds (20). *Salpingogaster* larvae are common in natural froghopper communities, where they may be found, at least in small numbers, practically throughout the year. In the cane-fields, they are usually abundant only during the later months of the year (September to December). They are of some economic significance, and have been estimated to destroy as much as 40 per cent. of the froghopper populations in one year (11). The more active Attid spiders are difficult subjects

for quantitative study, but they are often extremely abundant, and doubtless have an effect on froghopper populations, more particularly, however, from their attacks on adult froghoppers than on nymphs.

Of still greater importance than the predators, are the entomogenous fungi, *Metarrhizium anisopliæ* Sorokin, and *Empusa* sp., which freely attack adults in the cane-fields when climatic conditions are suitable. In the forests, neither of these fungi is known to attack froghoppers, though the evidence suggests strongly that they may do so, and that the absence of records is due to the difficulty of finding dead infected insects (11).

Ecological relations in the cane-fields have received considerable attention. As an account of such studies has already appeared (11), and moreover, since such studies are not carried out in the case of the other froghoppers considered in the present paper, their further discussion here is omitted.

(*c*) *Tomaspis pubescens* FABR.

This froghopper is very widely distributed in the American tropics, but, in the West Indies, it is not recorded outside Trinidad, which has closer affinities in flora and fauna with the mainland than with the other islands. The series in the author's collection include specimens from Trinidad, Venezuela, British Guiana, Surinam and Brazil. Structurally, as China and Myers (1) state, this species is remote from all the other species considered in their morphological studies. Probably the nearest relative is *Tomaspis basalis* Walker from Jamaica, which closely resembles it in the structure of the male genital armature, particularly of the aedeagus.

Like *T. saccharina*, *T. pubescens* is a grass-feeding species which favours thin forest shade, as already indicated (p. 57). On the whole, it frequents more humid situations than the preceding species, but the ranges of the two insects overlap considerably. In contra-distinction to *T. saccharina*, the eggs are laid among the roots of the host plant, in the dead tissue of the basal leaves, and only exceptionally in the soil. Consequently, given sufficiently humid conditions, *T. pubescens* may be found infesting grass growing in loose sand, which would definitely be avoided by *T. saccharina*.

The eggs of *T. pubescens* are appreciably larger than those of *T. saccharina*, although the average size of the adults is smaller, and they may be distinguished from them by this feature as well as by their distinctly reddish tinge, at least after a few days of incubation. The incubation period is about 14 days, but it is not so variable as that of *T. saccharina*. Furthermore, the eggs do not exhibit marked powers of aestivation in dry conditions.

The nymphs secrete a froth of a characteristic gelatinous consistency, which, on drying, exhibits granular concretions of unknown composition. The inhabited spittle masses usually occur in the axils of green leaves a few inches above the soil level, and not in intimate association with the roots.

In Trinidad, *Tomaspis pubescens* affects many of the same plants which are known to be hosts of *T. saccharina*, though the list of known hosts is more restricted. It has been observed infesting *Paspalum conjugatum*, *P. decumbens*, *Panicum polygonatum*, *Panicum zizanioides*, *Axonopus compressus* and *Ichnanthus tenuis* (*vide* Fitz Gerald, 15). This list also includes most of the hosts on which the author has encountered the species in other countries. On the margins of the Essequibo River in British Guiana, *T. pubescens* was found chiefly on *Paspalum conjugatum*, and in a new clearing on the Cattle Trail at Kurupukare, it was found attacking *Axonopus compressus*. It did not appear in similar situations on the Rupununi River. In the parts of North Brazil visited, the species was not generally common, and was found only at the mouth of the Rio Branco attacking *Paspalum conjugatum*, and attacking *Panicum zizanioides* near the Cachoeira de Panàma on the Rio Parù. In this last locality, the host plant was growing on a sand bank near the water's edge and extending into a deep overflow pool. The grass on the elevated bank was infested by *T. pubescens*, while the same grass growing in the deep water supported *Tomaspis tristis*, there being no overlapping of the two infestations (Fig. 7).

The natural enemies of this froghopper in Trinidad include *Salpingogaster nigra* Schiner which is much less abundant on this host than on *T. saccharina*. Experiment has shown that larvae of this predator, transferred from nymphs of *T. saccharina* to those of *T. pubescens*, rarely survive. One specimen of the same, or of a closely related species of *Salpingogaster*, was reared from a larva found in a *pubescens* spittle mass on the Rio Parù. Egg parasites are also relatively scarce. The eggs are occasionally attacked by a species of *Anagrus*, which is distinct from the species attacking *T. saccharina*. One case of parasitism by *Oligosita giraulti* has also been observed. As in the case of *Tomaspis saccharina*, nymphs and adults are preyed upon by Attid spiders.

### 3. Species Associated with High Forest.

(*a*) GENERAL.

Three species of *Tomaspis* occurring in high forest are known to the writer, one of which appears to be undescribed, and is known only from a single specimen. Consideration of this species is accordingly deferred. These species differ from those mentioned hitherto in their feeding habits, as none of them is grass-feeding. All the species appear to be primitively associated with the dense and complex tangle of roots of epiphytes which occur at the bases of the forest trees, notably Aroids (*Philodendron et al*). Froghoppers of this category were studied in Trinidad and in Brazil.

(*b*) *Tomaspis rubra* LINN.

This species is another froghopper widely distributed in the New World. It occurs in Trinidad and Grenada and additional localities mentioned by Fowler (2) are Indiana (North

America), Mexico, Guatemala, Panama, Colombia, Venezuela, Surinam, Peru and, in Brazil, the Rio Negro, Bahia and São Paulo.

China and Myers (1) are unable to relate the species to any of the groups which they have established. The male genitalia are highly characteristic, and serve for critical identification of this species (13).

*Tomaspis rubra* in Trinidad frequents four different habitats, and feeds in each case upon a different host*. At low altitudes, the insect may be found in secondary growth on *Eupatorium odoratum* (Compositae). In the forest, on rocky or unstable slopes of wet ravines, another Composite host, *Aspilia nigropunctata* is attacked. At an elevation of about 1,000 feet in mountain rain forest (Mt. Aripo), *T. rubra* has been found on the roots of *Carludovica palmata* (Cyclanthaceae) in densely shaded areas. Still higher up the mountains, at about 2,500 feet altitude, the insect becomes common on the epiphyte root-complex, particularly on Aroids, either at ground level or for a distance of some 12 feet up the tree trunks (c.f. Williams; 20, p. 64). That the insects from all of these habitats are conspecific has been shown by examination of the male genitalia.

As may be expected, infestations on *Eupatorium* have been most closely studied in the past, since this host is the most easily accessible. The eggs are laid in the tissues of the roots nearest the soil surface, where they are extremely hard to discover. In the case of the other hosts which have not long been recognised, the situation of the eggs is unknown, and no egg parasites have been discovered. When the nymphs occur on Aroid roots, the spittle masses are exposed and are easily seen. On the other hosts, however, they occur some distance below ground, often as deep as eight inches, and can only be discovered by uprooting the host plant and searching amongst the roots.

The only natural enemy known is the Syrphid *Salpingogaster pygophora* Schiner, recorded by Urich (15, Vol. III, p. 34) from an infestation on *Eupatorium odoratum* near Rio Claro, Trinidad.

Specimens of this froghopper were taken at Santa Isabella, near Belem, Brazil by sweeping in secondary bush. The host in this case is not known.

(*c*) *Tomaspis lineola* Fabr.

Specimens of *Tomaspis lineola* have been taken by the author only in North Brazil, where ample opportunities occurred for its study. The species occurred solely in virgin forest, and no secondary hosts are known. While nymphs were occasionally found attached to Aroid roots at the foot of living trees, they were found much more plentifully in wet decaying logs, which had been penetrated by the roots of these epiphytes (fig. 3). One curious infestation occurred in the forest at Taperinha near Santarem, where a small termitarium of *Armitermes percutiens* Emerson (det. A. M. Adamson), on the ground was built around, or had become invaded by epiphyte roots which emerged from its surface on all sides. Almost every one of the projecting rootlets bore an exposed spittle mass at its apex.

Froghoppers of this species were found widely distributed in the Lower Amazon, but the insects were never particularly numerous, and their discovery entailed prolonged search. The forest areas from which specimens were obtained were: Rio Parù (C. de Panàma), Taperinha, Rio Arapiums (upstream from C. do Arawan), Tauary (right bank of the Rio Tapajoz), São Raymundo (left bank of the same river). It is possible that more than one species was included under this name, as the series collected shows some variation in marking.

No natural enemies of the species were discovered, and eggs were never isolated from the fairly abundant material examined. A few shrivelled and dead nymphs were found, still in the remains of spittle mass, possibly indicating bacterial or fungus attack, since no parasites could be detected and there were no external signs of attack by predators.

### 4. Savannah Froghoppers.

(*a*) General.

The savannah froghoppers included in the present studies all occur in North Brazil, where savannahs of various types occupy a great proportion of the territory draining to the River Amazon and its tributaries. While a detailed botanical study of these savannahs has not been attempted, it may be stated that the chief grass is *Paspalum carinatum*, which occurs as an almost continuous carpet, except where islands of dense bush or of swamp and rain forest intrude. Locally, other grasses become dominant, notably *Trachypogon plumosus* and *Andropogon* sp., and in one case, a local dominant species in the wetter parts of the savannah is a sedge, *Rhynchospora* sp. The density of the shrub and tree vegetation varies considerably from place to place, presenting all gradations from an open, treeless savannah to a closed type ("*campinho*"), in which the grassland is confined to small areas between the bush "islands". The grass carpet usually comes to an end a few feet away from the bases of the trees and shrubs of the islands.

(*b*) *Tomaspis picklesi* China and Myers.

This interesting species appears to be of extremely local distribution, and is recorded only from the savannah area lying between the town of Santarem at the confluence of the Tapajoz with the Amazon, and the Serra de Cururù, near Alter do Chão, on the right bank of the Tapajoz, some 18 miles away. Considerable search was made for this insect in other localities, but even across the Tapajoz on the grasslands bordering he Arapixuna Creek, no trace of it was found.

* Monte (As Cigarrinhas Sugadoras, Secretaria de Agricultura de Minas Geraes, Serie Agricola, num. 9), mentions *Tomaspis rubra* as attacking sugar-cane in Brazil. As this, however, is not a personal observation of that author, and as, moreover, the statement is contrary to all known experience of the species elsewhere, it is open to considerable doubt.

The savannah frequented by this insect is undulating, and the open stretches are rather restricted, being interrupted at frequent intervals, particularly in the valleys, by large and dense bush islands (fig. 4). The soil is of a loose white sand, giving a slightly acid reaction to colorimetric test. The typical dominant grass is *Paspalum carinatum*, interrupted in places, especially near the large termitaria which are a significant feature of the landscape, by *Trachypogon plumosus*.

*Tomaspis picklesi*, originally discovered in this area by Mr. D. V. FitzGerald in July, 1932, infests *P. carinatum*, but is only abundant on this host where it is shaded by bush. The nymphs usually occur only in isolated clumps of the grass where it thins out near the foot of the trees. Nymphs may very occasionally be found in more open places. Adults do not remain in the open on *P. carinatum* during the daylight hours, but seek the denser shade offered by *Trachypogon*. They even appear to move round with the sun in bush island habitats, so as always to remain in shade.

The young nymphs are found on the roots of the host grass, and at the bases of its closely packed stems, usually about an inch below the surface of the soil. They are extremely difficult to discover unless a breeding ground can be detected by catching adults in the sweep net, when the grass may be uprooted, usually revealing numerous nymphs. The nymphs are more easily seen when about to emerge as adults. A little before dawn, they creep up the leaves and stems and, after attaining as high a position as possible, they secrete a new spittle mass of rather drier consistency, inside which emergence takes place. Emergence is complete by about 9 a.m., and within another hour, no trace of the emergence chamber is left, as the froth quickly vanishes in the heat of the sun.

The eggs are laid among the roots and between the leaf bases of the grass, and also in the sand in which the host is growing. So far as can be determined by careful examination, they are not inserted in dead or living host tissue. They appear to be able to withstand rather extreme heat and drought conditions. The temperature of the sand often attains 52° C at midday in the dry season, and nymphs are found in fair quantity with the first rains after nearly 60 rainless days.

Fully grown nymphs are quite small, and differ from most *Tomaspis* nymphs, which have a black thorax and wing pads, in being entirely white. The wing rudiments alone become dark a few hours before emergence.

This species is markedly seasonal in occurrence, humidity apparently being the controlling factor. Thus, on the author's first arrival in Santarem in August, 1933, only three nymphs and a few adults were found during the month after very careful search. These individuals apparently represented the end of the wet season infestation which had just cone to an end, following a July rainfall of 3.44 inches. Frequent observations were made during September and October (at least bi-weekly visits to suitable localities), but not a single specimen of any stage was found until 17th November, when a fairly large infestation of young nymphs was discovered in one of the localities regularly visited. This outbreak apparently occurred in response to the heavy rains of early November. Thereafter, the insects became more and more plentiful, especially after the end of December when the wet season proper commenced. They were still abundant at the end of March, when the Brazilian investigations terminated. The monthly rainfall at Santarem for the year 1932 is given in the Appendix and may be taken as representative of the general climate of this area.

Numerous dissections of nymphs were made, and many nymphs taken in the field were reared to maturity, but no parasites were discovered, except a Mermis worm which was found to affect some three per cent. of the nymphs during March, the only month in which this parasite was found. Isolation of the eggs was difficult, but some 200 eggs were obtained, and none of these was parasitised. During the whole period in which this froghopper was under observation, no symptoms of fungus attack were observed on adults or nymphs. Freedom from fungus attack is probably due to the dryness of the habitat in which the insect lives.

The species is undoubtedly a true savannah froghopper, and has been encountered only in the type locality and on the one species of host.

### (c) *Tomaspis incompleta* WALKER.

*Tomaspis incompleta* is stated by China and Myers (1) to frequent "forest clearings and margins". While the author agrees with this statement, there is good reason to believe that such localities do not represent the true natural habitat of the species, which should properly be regarded as native to moist savannahs above the region of seasonal inundation. The species has a wide range in the Lower Amazon basin, and two of the localities in which it was studied are over a thousand miles apart. Little appears to be known of the species in other countries.

The number of hosts attacked by the species is great, and the insect in this respect presents a marked contrast to the preceding species. In cultivations, *Paspalum conjugatum* seems to be commonly attacked throughout the range investigated. Even on this host (a typical grass of forest clearings), *T. incompleta* frequents more open and exposed situations than would be favoured by the typical froghoppers of forest edges. At Fordlandia on the Tapajoz, the insect was abundant throughout the young rubber cultivations, in which the trees were newly planted and did not cast any appreciable shade. It occurred here wherever local failure of the cover crops had allowed weed grasses to grow. In a large clearing between the wharves and the factories, many grasses, including *Oryza latifolia*, were infested, and the insect was abundant between the sleepers of the railway tracks and on *Cynodon dactylon* on the closely-mown lawns of the staff residences.

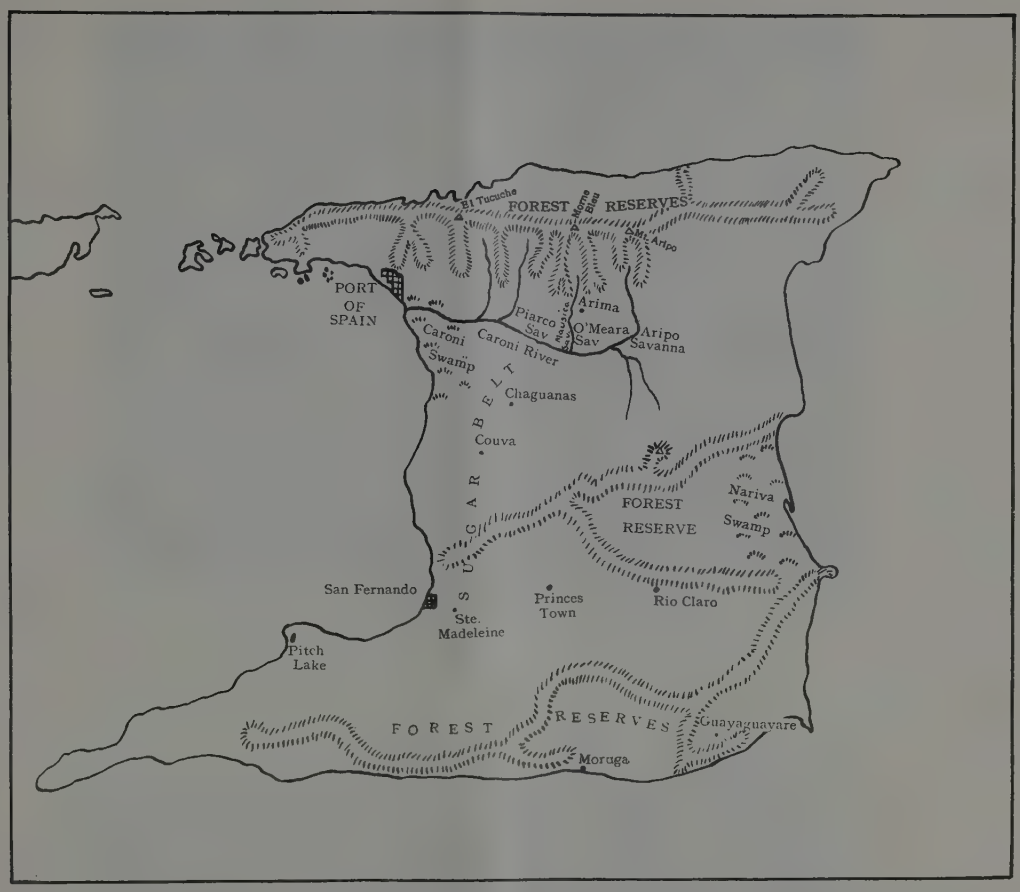


FIG. 1.—SKETCH MAP OF THE ISLAND OF TRINIDAD.

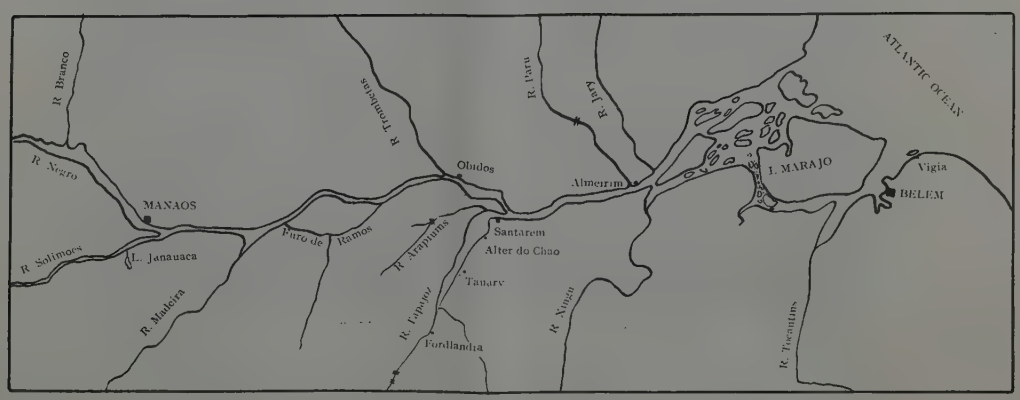


FIG. 2.—SKETCH MAP OF THE LOWER AMAZON BASIN SHOWING REGIONS IN WHICH STUDIES WERE CONDUCTED.

FIG. 3.—Nymphal spittle of *Tomaspis lineola* Fabr., infesting Aroid roots in a decaying log, Rio Arapiums, Brazil.

FIG. 4.—Portion of savannah near Santarem, Brazil; a haunt of *Tomaspis picklesi* C. and M. The grass clumps to the left are composed of *Trachypogon plumosus*, while the remainder consists of *Paspalum carinatum*.

FIG. 5.—*Paspalum carinatum*, infested by *Tomaspis incompleta* Walker. The taller grass to the rear is *Andropogon* sp. Tauary, Rio Tapajoz, Brazil.

FIG. 6.—Spittle of *Tomaspis tristis* Fabr. at the base of *Echinochloa spectabilis*, Rio Amazon, near Ituki, Brazil.

FIG. 7.—Spittle of *Tomaspis tristis* Fabr., on *Panicum zizanioides*, Cachoeira de Panàma, Rio Parà, Brazil.

The small sugar cultivations here were not affected by the froghopper, but grasses in the open traces a few feet away were abundantly infested. There is, nevertheless, some reason to believe that *Tomaspis incompleta* may attack sugar-cane. In a small sugar cultivation at Janauacà, near the confluence of the Solimões and the Rio Negro, three adults were taken on cane, though nymphs were found only on *Paspalum conjugatum* in the traces. The visit to this district was made during the dry weather, soon after arrival in Brazil, when froghoppers would be expected to be at a minimum, but unfortunately, owing to the difficulties of inter-state travelling there was no opportunity of paying a second visit there. The proprietors stated that the insects were more abundant at the opening of the rainy season, when "*Bichinhos spumandos*" (nymphs) could be found in some quantity around the roots of the canes. They did not associate any disease of the cane with the presence of the insects in numbers.

Along the road from Belem to Vigia, the insect appears to be common throughout the year, as might be expected from the well-distributed rainfall of the district. It attacks chiefly *Paspalum conjugatum* growing in the more open spaces on the roadside, but seems to disappear before the region of the small savannahs is reached.

At Tauary, on the right bank of the Tapajoz, the insect was found in an apparently natural habitat during March 1934. The vegetation of the banks of this part of the river is predominantly forest, but a series of three small savannahs occurs. These are very different from most of the savannahs already described, having little or no bush flora, and extending at most over 100 acres each. The centre of the space is occupied by *Paspalum carinatum*, which is replaced by *Andropogon* sp. some yards before the forest commences (fig. 5). Both these grasses were found to be thickly infested with *Tomaspis incompleta*.

The eggs are laid in the soil in which the host plants grow and amongst the roots. Many of them were examined and incubated, but there was no sign of parasitism. The nymphs occur at ground level, and, when about to emerge as adults, they appear to be particularly susceptible to the attacks of an entomogenous fungus (probably *Empusa* sp.), which attaches the insect to the summit of a grass blade. The nymphs are also preyed upon by a *Salpingogaster*, one specimen of which was obtained at São Raymundo, Rio Tapajoz. The fungus appears to be of more general importance. It was observed both near Belem and in all the Tapajoz districts. As many as 30 per cent. of the nymphs were attacked by it.

(*d*) *Tomaspis rhynchosporae* China and Myers.

A third froghopper species, associated with savannah vegetation, was encountered near the town of Vigia, about 100 miles from Belem. This species is one of the smallest known representatives of the genus, not exceeding 0.6 mm. in length. The type material was obtained from Mt. Roraima on the borders of British Guiana and Venezuela but the only material studied by the author was obtained from Vigia.

The insect breeds on a sedge, *Rhynchospora* sp., and the nymphs feed on the green leaves as well as on the roots. When this infestation was studied (September 1933 and January 1934), the sedge was very small, and formed discontinuous tufts in an area of damper ground bordered by *Paspalum carinatum*. The nymphs were most numerous where the host plant occurred under the slight shade cast by a few isolated trees. The nymphs examined were all unparasitised, except one living nymph having a mass of black fungus hyphae beneath the cuticle of the thorax. Eggs were not found, and no predators of nymphs or adults were discovered.

### 5. River-Littoral Species.

(*a*) General.

The level of the water in the Lower Amazon exhibits great seasonal variations. The extent of the rise and fall tends to be minimised by the fact that the tributaries of the left bank, coming from the north of the equator, contribute their greatest volume of water during the season when the southern tributaries are declining. The Andean tributaries, which supply the greatest volume of water, reach a high level from the melting of the snows at about the same time as the rain-fed southern tributaries are highest. The net result is a rise in the level of the Lower Amazon towards the end of December, which continues until the middle or end of May, after which the level once more falls rapidly. This rise and fall of the river level, which in some places may be 16 metres (12), is naturally a significant factor in the life of the littoral vegetation.

In consequence of the changes in water level, extensive areas of the margins of the river are dry land at certain seasons of the year and are deep, navigable lakes at others. To the plant inhabitants of such areas, and to plants of the banks of the river and its islands, rainfall is of secondary importance, their activity being controlled by the height of the water.

Corresponding to the duration of the submergence of the successive strips of the river bed between the summer and winter levels of the river, there is a zonation of the flora, which is composed almost exclusively of grasses. If the margin of the river be examined at the period of high water, the first grass zone encountered when approaching the bank from the centre of the stream consists of a floating or lightly-anchored grass, *Paspalum repens*. Masses of this grass, together with smaller masses of various other species, often become detached by the current and form large floating islands. These are carried down-stream and into the bays and seasonal lakes of the river, where they may extend so as to cover areas often many acres in extent. As the river bank is approached further, a zone of vegetation somewhat variable in composition occurs. This is

composed of *Oryza latifolia*, *Luziola spruceana*, and a grass known locally as "*tabokinha*". These grasses are purely aquatic. When the river margin which they occupy becomes dry ground, they may root in the damp soil, and new flushes of growth may occur, which wilt and die as the water recedes more and more.

A third zone, nearer the river bank, is occupied by an important fodder-grass known as "*canarana*" (*Echinochloa spectabilis*). This grass is firmly rooted in the soil, and for several months of the year, it is remote from the water's edge. It continues to grow, though not so luxuriantly, during the dry season. This grass is chiefly found occupying the river banks, but it also forms extensive tracts in the seasonal lakes. A fourth grass zone, most remote from the water, has its roots submerged only for a few days or at most, weeks, when the river attains its very highest level. The grass composing this zone is "*morim*" (*Paspalum fasciculatum*). It is a very tall species, often extending some distance inland, where it presents the appearance of a well-grown sugar-cane field.

Grass communities of this type are not found in the blue-water tributaries such as the Tapajoz, but appear to be associated with rivers containing large amounts of suspended matter. It is of interest to note, however, that, in the Furo de Maica, where all the grasses mentioned occur in profusion, the water during the earlier parts of the rainy season is blue, being derived from the Tapajoz, but is yellow Amazon water for the rest of the year. The nearby channel of Ituki contains Amazon water throughout the year.

(*b*) *Tomaspis tristis* FABR.

Adults of this species were occasionally taken at light at Santarem in October, but no nymphs were discovered until the following January, when *Echinochloa spectabilis* in the grass community already described, was found to be very heavily infested. More extended search showed that the froghopper was abundant almost wherever the grass occurred, provided it was rooted either in the water or within a few inches of the river. At Taperinha, on the Furo de Maica, this insect was found abundantly on a variety of grasses in localities which had been diligently searched without success during the preceding October. The hosts on which the froghopper was found were: *Echinochloa spectabilis* (both banks of the Amazon from the mouth of the Tapajoz to the Xingu), *Oryza latifolia*, *Luzeola spruceana* and "*tabokinha*" (Taperinha), *Paspalum conjugatum* (Taperinha and Campo da Velha Pobre), *Panicum zizanioides* and *Olyra* sp. (Rio Parù). Sugar-cane was occasionally found to be attacked in small cultivations on Arapema Island, near Santarem. Williams found the same species attacking sugar-cane in some quantity in Surinam (19).

*Tomaspis tristis* was most abundant on *Echinochloa spectabilis*; the other riparian grasses were less affected, while the insect was never observed on *Paspalum repens*. The infested *Paspalum conjugatum* at Taperinha occurred in a swampy area associated with an outcrop of impervious clay at the foot of a hill about a quarter of a mile from the edge of the Furo de Maica. This area had been given special attention during an earlier visit in October, 1933, but at that time, there had been no trace of an infestation. Occasional nymphs were also found on the same host on a path up the slopes of the hill in the shade of the forest.

The infestation on *Olyra* sp. on the banks of the Rio Parù occurred where the rain forest proper commenced, about 50 feet up a steep slope. The *Olyra* formed a dense thicket about 15 feet wide along this contour, and the bare grass haulms bore a few spittle masses. Only 20 nymphs in all were obtained, of which five were parasitised by Mermis worms.

The eggs, at any rate in the wet season, are laid on the blade of the green leaves of *Echinochloa*; eggs were not found on other hosts. They are laid in clusters of 30 to 40, and the leaf tissue around the clusters becomes discoloured and brown, but does not dry out. This is the only noticeable damage which the plant suffers. The incubation period occupies about 20 days. The nymphs principally infest the axils of the upper leaves though they sometimes occur near the roots when these latter are not submerged (Fig. 6). The spittle masses contain up to 20 nymphs each; the nymphs present in one mass are of various ages.

Large numbers of eggs and of nymphs were examined for parasites. The only nymphal parasites discovered were the Mermis worms already mentioned. Some 13 per cent. of the eggs were parasitised by an undetermined Hymenopteron. Parasitism of the eggs of *T. saccharina* occurs to this extent in Trinidad, however (*supra*, p. 57), and having regard to this and to the fact that *saccharina* eggs are laid chiefly in the soil and never in green tissue, this parasite was not considered to be of economic value for introduction into Trinidad. No predators of any stage were observed.

(*c*) *Tomaspis morialis* CHINA AND MYERS.

The only known host of this species is "*morim*" (*Paspalum fasciculatum*), the member of the riparian grass community which occupies the zone most remote from the water. In common with the other littoral grasses, this host plant received considerable attention during the dry season, but no froghoppers were found on it until after the rains of early November, 1933. After this date, infestations were very heavy. Since this is the grass of the riparian community which is the most remote from the water, it is probable that it is more influenced by direct rainfall than are its more aquatic neighbours.

Curiously enough, no eggs of this species of froghopper were ever obtained, although many attempts were made to find them. Both green and dead leaves of infested plants were examined, the soil in which infested plants were growing was washed and searched, and parts of the plant

were incubated for several days in the hope that any eggs present might hatch, but all these methods failed to reveal their location.

As in the case of *T. tristis*, the nymphs infest the upper axils of the leaves, to which they are even more strictly confined than are the nymphs of the former species. Up to 20 nymphs of various ages inhabit one spittle mass.

The discovery of a small social wasp, *Polybia rejecta* Fabr., preying upon the nymphs of *Tomaspis morialis*, aroused considerable interest. The wasps were observed to fly around the infested plants, particularly near the axils in which nymphs occurred, and would occasionally alight and probe the spittle masses with their mandibles. Sometimes a wasp would pull out a large nymph and then proceed to bite through the chitin of the dorsal side of the thorax. The prey was then bundled up by folding the head and anterior part of the thorax underneath, and the captor flew away with it, apparently grasping it by means of the mandibles and the front pair of legs. It was observed that prey was extracted from only a few of the spittle masses visited, though all contained several nymphs. Probably the nymphs are only taken when they occur quite near the surface of the froth mass.

Examination of a nest of these wasps showed that froghoppers formed only a very small proportion of their food. The prey chiefly found in the nest was a minute white caterpillar, and it was accordingly concluded that the wasp would not serve as an economic control of froghoppers.

Some thousands of nymphs were dissected or reared to maturity, but there was no sign of parasitism, and the only natural enemy discovered was the wasp predator above mentioned.

### 6. Other Species.

Two further species of froghopper studied by the author remain for consideration. As these have not been encountered in primitive habitats, they cannot be assigned to any of the habitat groups already discussed. The species in question are *Tomaspis guppyi* Urich, and *Tomaspis basalis* Walker.

#### (*a*) *Tomaspis guppyi* Urich.

This species is synonymised by China and Myers with *T. tristis* Fabr., which it closely resembles, and to which it is undoubtedly closely related. Some little time after the publication of his joint paper, however, Mr. China mentioned to the author that he considered *T. guppyi* to be a distinct species, from a comparison of the paramere structure in the males of the two series. Subsequently, the author examined a series of each species and concurs in this opinion. That *guppyi* is distinct from *tristis* appears to be supported from a consideration of the egg-laying habits, as will appear.

*Tomaspis guppyi* seems to be confined to Trinidad, where, however, it cannot be considered a common insect. It is encountered only in a few localities, where it may be locally abundant, and it appears to be of more frequent occurrence in the south of the island than in the north. One specimen in the author's collection, however, was obtained by sweeping roadside grasses near Morne Bleu in the Northern Range. A favourite host is the grass *Setaria sulcata*, a common weed of cacao cultivations. Where this grass is particularly luxuriant through neglect of cultivation, very dense infestations may occur. Williams records the insect attacking a species of bamboo (20, p. 64), an observation which has since been confirmed by FitzGerald who has also found *Panicum zizanioides* to be a host (15, Vol. IV, p. 373).

The eggs are larger than those of *T. saccharina*, but, as in the case of this species, they are laid in dead leaf tissue of the host and, somewhat less abundantly, in the soil in which the host plant is growing. Incubation of the eggs occupies about 20 days, and there does not appear to be a marked diapause. The habit of oviposition in dead tissue and in the soil contrasts rather markedly with the habit of *T. tristis* which, as we have seen, lays abundantly in the green tissues of the host.

The nymphs after hatching wander up the stems of the host and become established at a height of about six inches above the ground, as Williams has already noted. They do not usually seek the axils of the leaves as in the case of *T. tristis*, though this difference might be due to variations in micro-climate of the infestations studied. When fully grown, the nymphs closely resemble those of *T. tristis*, especially in the colour of the abdomen which is somewhat olivaceous-green. Nymphs about to be transformed into adults seek a still higher position on the host, often coming to rest on the blade of a leaf. A new spittle mass of a characteristic texture is then secreted, within which emergence of the adult takes place.

Numerous examinations of the eggs of this species have been made for parasites, but none has yet been discovered. Parasites of the nymphs are likewise unknown, in spite of the numerous dissections made. Nymphs and adults are preyed upon to some extent by Attid spiders.

*Tomaspis guppyi* is occasionally found in the cane-fields, but never in such numbers as to represent a danger to the crop. The first recorded instance of a cane-field occurrence was at Ste. Madeleine, South Trinidad, in 1929, but more recently, the insect has been found in the fields of estates in the Central Plain (*vide* FitzGerald (15) Vol. IV, p. 235).

#### (*b*) *Tomaspis basalis* Walker.

Gowdey's *Catalogus* (4) records three species of *Tomaspis* from Jamaica, referred to the genus *Monecphora*, viz.: *basalis* Walker, *bicincta* Say and *jamaicensis* Distant. During the author's visit to Jamaica in 1929-30 (8), only the first of these was encountered. *Tomaspis basalis* exhibits marked sexual dimorphism, and the males of a collected series closely resemble *Tomaspis bicincta*, which is recorded in Cuba and in North America. It seems possible that *bicincta* is

recorded from Jamaica on a mistaken identification of the male of *basalis*. None of these species was represented in the collection of the Department of Agriculture in Jamaica.

The single infestation of *Tomaspis basalis* occurred on the introduced grass *Anatherum zizanioides*, which had been planted to protect the banks of an irrigation flume in a banana plantation, Agualta Vale Pen, near Annotto Bay. The infestation was extremely local, and the insects were few in number. A representative series of adults was obtained, and some 35 nymphs were examined for parasites, but none was found. The nymphs were preyed upon by the larvae of a species of *Salpingogaster**, awaiting identification at the British Museum. A few eggs discovered in moist, dead leaf bases, were found to be unparasitised, and to exhibit the phenomenon of delayed hatching which is so marked in *T. saccharina*. At the time these studies were made, the technique for obtaining froghopper eggs from soil had not been elaborated. Considering that the visit to Jamaica was made in the dry season, when froghopper breeding is at a minimum, there would appear to be ample room for further study of this species.

*Tomaspis basalis* presents some morphological similarity to *T. pubescens*, to which it appears to be related. The existence of "diapause eggs" is a physiological link with *T. saccharina*, and further study may show that *basalis* is another species associated with forest edgings and clearings.

### 7. Conclusions and Summary.

The eleven species of *Tomaspis* discussed show that the genus has colonised four very distinct types of habitat. Most of the species studied are pre-eminently grass-feeding insects, but the members of one ecological group, the inhabitants of high forest, so far as is known at present, differ from their relatives in the other groups in being attached to other plants, especially to epiphytic aroids. Certain of the typically grass-feeding species occasionally breed on members of the related family Cyperaceae, and this trend appears to have become most marked in the case of *Tomaspis rhynchosporae*, which is confined to this family and does not appear to attack grasses.

Most of the species discussed infest a wide range of hosts, and indeed may be said, as Myers has already mentioned (7), to be more attached to a particular plant community than to a particular plant host. To this generalisation, however, there appear to be one or two notable exceptions. Such exceptions include *Tomaspis picklesi*, which appears to be confined to the host *Paspalum carinatum*, and *Tomaspis morialis*, which is equally restricted to *Paspalum fasciculatum*. Other species, on the contrary, while exhibiting some preference for a definite habitat type, may be said to show affinities with two plant communities. A good example of an insect of this type is *Tomaspis incompleta*, which appears to be intermediate between the savannah froghoppers proper and the froghoppers of forest margins.

The savannah froghoppers possess particular interest, since their natural enemies would have to be adapted to marked seasonal variations typical of such a habitat, and would accordingly be most likely to survive cane-field conditions on introduction into Trinidad. Savannah froghoppers, furthermore, have only recently been recognised, and were unknown prior to 1932, when representatives of this biological group were discovered by Myers and FitzGerald (15, Vol. IV, p. 117).

*Tomaspis rubra* is peculiar in affecting host plants belonging to widely separated natural orders, its hosts, including Compositae, Cyclanthaceae and Araceae.

Most of the species studied are markedly seasonal in activity over the greater part of their range. The effect of seasonal climate is most marked in the case of savannah froghoppers and of the froghoppers infesting riparian grasses, and least marked in the case of forest froghoppers. Humidity is the principal factor involved, as is evident from a study of those areas, such as the Belem district, in which the rainfall is more evenly distributed over the year (*vide* Appendix). In this area, *Tomaspis incompleta*, for instance, is active throughout the year. Similarly, in Trinidad, the effect of an unusually rainy dry season is to cause the emergence of froghoppers in the cane-fields during those months in which they are normally in abeyance.

From the economic viewpoint, the information presented here is not encouraging. The natural enemies encountered are few in number, and mostly essentially the same in nature as those already known in Trinidad; they are of limited effect in controlling froghopper populations. The most efficient natural enemies are evidently the entomogenous fungi, which, of all the biotic factors of insect control, are the least amenable to exploitation, since they depend intimately on variable climatic conditions. The most important predators encountered throughout the range studied are Dipterous larvae of the genus *Salpingogaster*. Their efficiency, however, is strictly limited, and little advantage would be gained by transferring closely related species of this genus from other countries into Trinidad, where two species are already known. It would appear that the froth with which the nymphs of all species are covered is an efficient protection against the attack of most parasites and predators. Similarly, the eggs of most species are well concealed, either in underground parts of the host

* The specimen reared was close to *S. nigra* Schiner, the only species of this genus recorded from Jamaica.

plant or in the soil itself. In this connection, it is interesting to note that, in the case of *T. saccharina* in Trinidad, those eggs which are laid in cane-trash are parasitised to a significantly greater extent than are those laid in soil (11). Of the Brazilian froghoppers, egg parasites were only discovered in the case of a species (*T. tristis*) whose eggs are laid in a relatively exposed position on the leaves of the host plant.

Recent studies such as the present show, however, that savannah froghoppers are at any rate less unusual than was formerly supposed. Some of these species further appear to be extremely restricted in range and it is possible that the extensive savannah regions of Central Brazil may prove to be the home of other savannah froghoppers which might repay investigation.

The studies discussed above, extending as they do over a period of years, would obviously have been impossible without the co-operation and hospitality which have been extended to the author in all the countries visited. The author is especially indebted to Mr. D. V. FitzGerald, whose reports on the hosts of *Tomaspis saccharina* in Trinidad have been freely drawn upon. Particular acknowledgment is due to Mrs. Pickles, who, for seven months, shared the vicissitudes of camp life in Brazil.

## Appendix.

* Rainfall in Inches at Santarem and Belem, Rio Amazon.

| Month. | Santarem, 1932. | Belem, 1900-27. |
|---|---|---|
| January | 5.55 | 12.66 |
| February | 10.00 | 13.87 |
| March | 16.50 | 15.87 |
| April | 8.07 | 12.98 |
| May | 8.45 | 10.49 |
| June | 6.13 | 5.73 |
| July | 3.44 | 6.49 |
| August | 0.26 | 4.88 |
| September | 1.48 | 3.88 |
| October | 0.00 | 3.03 |
| November | 1.91 | 2.94 |
| December | 1.13 | 6.46 |
| Total | 62.92 | 99.28 |

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* For the Santarem data, thanks are due to Dr. G. Hagmann, who kindly communicated these figures with the consent of the Ministero de Agricultura; the Belem rainfall is adapted from Pinto (12).

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# SOME OBSERVATIONS ON MANSON'S EYEWORM OF POULTRY IN ANTIGUA, B.W.I., AND A SUGGESTED METHOD OF CONTROL.

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## Introductory.

The presence of Manson's eyeworm (*Oxyspirura mansoni*) has been reported from several countries in the world. With regard to its occurrence in the West Indies, Ransom (1) reports it from Jamaica, and Neveu-Lemaire also gives the "Antilles", but the reference is not available.

The writer wishes to record some observations on its presence in Antigua, B.W.I., as infesting both poultry and turkeys.

The worm is a small, threadlike nematode about five-eighths of an inch long. It is found under the membrane *nictitans* of the eye where its presence sets up considerable irritation to the host, as many as 32 worms being removed from one eye.

The symptoms observed due to its presence were severe lacrimation, scratching at the eye with the feet, rubbing the head against the wing, thickening and congestion of the membrane *nictitans*, an invariable symptom, and white spots on the cornea. Young chickens were much more affected than adult birds, many of them being blinded with death resulting, due to the inability to see to pick up food.

## Life Cycle.

The life cycle of this parasite involves an orthoptera vector, a species of cockroach, *Pycnoscelus surinamensis* (L). Suspected roaches were easily found out-doors, especially near poultry houses, their favourite abode being under loose leaves, stones and poultry manure. Specimens were secured and sent to the U.S. National Museum, Washington, where, through the kind courtesy of Dr. C. F. W. Musenbeck, Head of the Entomology Department, they were promptly identified by Mr. A. B. Guerney as being the above species.

Sanders (2) gives the life cycle as follows:—"Sexually mature male and female worms occur in the inner canthus of the eye, beneath the nictitating membrane. Here the female worms lay embryonated eggs. The eggs are washed down the tear-duct, with the eye fluid, into the pharynx and are swallowed. Some of the eggs may hatch in the intestinal canal, but most of them pass from the body with the faeces, where hatching occurs in a variable length of time. The faeces are then eaten by the cockroach and the larvae finally reach the body cavity of this insect. Here further development takes place after which the larvae free themselves from the capsule and wander around in the body cavity, legs, &c., of the roach. The roaches are readily eaten by chickens, and the larval eyeworms contained in these insects having gained a position in the mouth pass into the eye, through the naso-lacrymal duct. In case the roaches are swallowed whole, and the larvae reach the crop of the fowl, they free themselves from the intermediate host and migrate up the oesophagus into the mouth, thence to their destination through the tear-duct. They reach sexual maturity in the tear-sac, beneath the nictitating membrane and lay their eggs".

## Treatment.

The initial treatment for the destruction of these worms *in situ* consisted in lifting the membrane and instilling a few drops of a two per cent. solution of lysol. This was found to destroy the worms, but rather slowly. Forceps were then used to remove all the worms, and the eye washed out. It was found, however, on subsequent examinations of the eyes thus treated, at intervals of a few days, that there were just as many worms to be found as before.

The idea of removing the normal habitat of this parasite, the membrane *nictitans*, suggested itself as a means of control, and the following experiment was carried out.

Six young chickens, about three months old, were obtained and placed separately in insect proof cages. A careful examination was made of the eyes to determine whether they were already harbouring the larvae or mature worms, and their droppings were also examined for the presence of eggs. After a week's daily examination which proved negative, the membranes from both eyes were removed from three of the chickens, the other three serving as controls.

The removal of the membranes calls for no special description as the operation is a very simple one. The haemorrhage was very slight and easily controlled. All the birds recovered very quickly, the area being healed over in about four days. The actual instillation of larvae into the eyes was not started until a week after the removal of the membrane. The membranectomized birds were numbered 1, 2 and 3, the controls 4, 5 and 6.

The material for infecting these chickens was obtained as follows:—

Several areas where eyeworm infestation was known to be established, were visited and a collection of cockroaches, *Pycnoscelus*, was made from around the poultry house. In all cases these roaches were found in large numbers and collections were made of practically all stages of development. They were placed in fruit-jar bottles with an open-work cap. Some material was scraped from the floor of the poultry house and placed in the jar under which material the roaches quickly hid themselves.

The mature roaches were first examined for the presence of larvae, the largest amount of infestation being found in a gravid female as follows:—

Twenty-three adult larvae—over 1 c.m. long.
Nine small larvae.
Nine cysts containing larvae.

The pre-adult forms were next examined, and they were also found to be heavily infested. A small nymph in about the third moulting stage yielded two large and one small larvae. The following infestations were carried out with the six chickens :—

Roaches were chloroformed and dissected open so as to disclose the larvae, only adult larvae being used, which were then distributed to the chickens as under.

*Chicken No.* 1.—(Membrane removed). (i) Six larvae were placed in each eye. (ii) Seven larvae were fed by means of the mouth, placing the larvae back on the tongue. (iii) Three cysts containing larvae were fed.

**Table I.**

MEMBRANE REMOVED. (5.10.37.)

| Date. | No. | Right eye. | Left eye. | Remarks. |
|---|---|---|---|---|
| 6-10-37 | 1 | + | + | |
| | 2 | — | — | |
| | 3 | + | — | |
| 7-10-37 | 1 | + | + | |
| | 2 | — | — | |
| | 3 | + | — | |
| 8-10-37 | 1 | + | + | |
| | 2 | — | — | |
| | 3 | + | — | Few right eye |
| 9-10-37 | 1 | + | + | |
| | 2 | — | — | |
| | 3 | + | — | Very few—right eye |
| 10-10-37 | 1 | + | + | |
| | 2 | — | — | |
| | 3 | + | — | |
| 11-10-37 | 1 | + | — | |
| | 2 | — | — | |
| | 3 | + | — | |
| 12-10-37 | 1 | + | — | |
| | 2 | — | — | |
| | 3 | + | — | |
| 13-10-37 | 1 | + | — | Very few—right eye |
| | 2 | — | — | |
| | 3 | — | — | |
| 14-10-37 | 1 | + | — | |
| | 2 | — | — | |
| | 3 | — | — | |
| 15-10-37 | 1 | + | — | |
| | 2 | — | — | |
| | 3 | — | — | |
| 16-10-37 | 1 | + | — | |
| | 2 | — | — | |
| | 3 | — | — | |
| 17-10-37 | 1 | — | — | |
| | 2 | — | — | |
| | 3 | — | — | |
| 18-10-37 | 1 | — | — | |
| | 2 | — | — | |
| | 3 | — | — | |
| 19-10-37 | 1 | — | — | |
| | 2 | — | — | |
| | 3 | — | — | |
| 20-10-37 | 1 | — | — | |
| | 2 | — | — | |
| | 3 | — | — | |

*Chicken No.* 4.—(Membrane not removed). This was treated in a similar manner to Chicken No. 1.

*Chicken No.* 2.—(Membrane removed). This chicken was fed with seven roaches, five adults and two pre-adults. Infestation of the roaches with larvae was assured, as a ten per cent. examination of the entire number of collected roaches showed infestation. This is proved by the No. 5 chicken, similarly treated being infested.

*Chicken No.* 5.—(Membrane not removed). This chicken was treated in a similar manner to No. 2.

**Table 2.**

MEMBRANES NOT REMOVED. (5.10.37.)

| Date. | No. | Right eye. | Left eye. | Remarks. |
|---|---|---|---|---|
| 6-10-37 | 4 | + | + | Larvae far under membrane. |
| | 5 | + | + | |
| | 6 | + | + | |
| 7-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 8-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 9-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 10-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 11-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 12-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 13-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 14-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 15-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 16-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 17-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 18-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 19-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |
| 20-10-37 | 4 | + | + | |
| | 5 | + | + | |
| | 6 | + | + | |

*Chicken No.* 3.—(Membrane removed) (i) Six larvae were placed in each eye. (ii) Six larvae were fed. (iii) Two cysts were fed. (iv) Two adult roaches were fed.

*Chicken No.* 6.—(Membrane not removed). This chicken was treated similarly to No. 3.

All the above experiments were carried out on 5th October, 1937. The chickens were then returned to their individual cages and examinations started on the following day.

After examinations proved negative for larvae for four consecutive days in the membranectomized birds, daily examinations were stopped and only periodical ones made in both groups. These all proved negative for Nos. 1, 2 and 3, and positive for 4, 5 and 6. Up to the date of this report, 22nd November, 1937, the conditions remain the same, no larvae in the membrane removed birds; and larvae, almost mature worms, in the controls.

The following observations were also made:—

Chicken No. 3 (membrane removed) was removed on 10th November, 1937, and three adult worms taken from an infested fowl were placed in each eye. The presence of these set up considerable irritation as was evidenced by the discomfort of the chicken. Rapid attempts were made to dislodge them by rubbing its eyes against the wing feathers, lacrimation was also profuse. On examination the following morning no worms could be found in either eye.

The writer realizes that it would be necessary to carry out further experiments on a large scale to determine definitely the practical value of such treatment. This report is made in the hope that others may try out the experiment.

The theory is suggested that the removal of the membrane renders conditions biologically unsuitable for the parasite to complete its life cycle due to alterations in the habitat, light and oxygen requirements. It also makes it possible for the host to dislodge these parasites from the eye, due to the absence of their protective covering.

The destruction of the vector, the cockroach, is of paramount importance in the control of the eyeworm. Dead or live roaches should not be fed to chickens. All droppings should be suitably disposed of and all loose boards, trash and dirt should be removed from poultry houses so as to destroy effectively the haunts of these insects.

**Summary.**

1. The presence of Manson's eyeworm, *Oxyspirura mansoni*, is reported from Antigua as infesting both poultry and turkeys.

2. Experiments were conducted where unsuccessful infestation followed the removal of the membrane *nictitans* from the eye.

3. The mature adult worm was found not to remain in a membranectomized eye.

**Acknowledgments.**

I wish to acknowledge my sincere gratitude and appreciation to Mr. H. E. Box, F.R.E.S., Colonial Development Fund Entomologist in Antigua for his great help, advice and encouragement in this problem and in preparing the report. I am also indebted to Dr. T. W. M. Cameron, Institute of Parasitology, Macdonald College, Canada, for having identified the nematode and to Mr. A. B. Guerney, U.S. National Museum, Washington, Entomology Dept., for similar service with regard to the cockroach.

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1. Ransom, B. H. — Manson's eyeworm of chickens, *Oxyspirura mansoni*, with a general review of nematodes parasitic in the eyes of birds, and notes on the spiny-suckered tapeworms of chickens. *U.S.D.A. Bureau Animal Ind. Bul.* 60, 3-72.

2. Sanders, D. A.—1928. *J. A. V. M. Assoc.* Vol. LXXII. (*N.S.* Vol. XXV), pp. 568-584.

## NOTE ON SELENIUM IN SOILS.*

The malady affecting live stock reared in certain sections of the great cereal-growing region of the north Central Plain of the United States (Nebraska, South Dakota, Wyoming), now known to be due to selenium poisoning, was originally attributed to "alkali trouble". The soil in these areas is an alkali type, occurring under rainfall of relatively low magnitude. It is derived mainly from the Pierre Shales of Cretaceous age, which contain seleniferous pyrite, the initial source of the selenium component. Quantities as low as one part of selenium per million parts of soil, although permitting normal growth and maturation of wheat plants, with no visible injury to the crop, nevertheless produced grain having toxic effects on stock. Only when the content of selenium in the soil exceeds 15 p.p.m. do stunting effects or "snow-white chlorosis" become noticeable in the plants. Wheat grain containing 8 to 15 p.p.m. of selenium may produce fatal results when fed to farm animals. The maximum selenium content of naturally toxic cereal grains is about 30 p.p.m. of their weight.

**Rainfall Effects.**

It is stated in the literature that the seleniferous soils of north-central U.S.A. retain selenium in their surface layers in amount sufficient to produce toxic vegetation of crops only in districts where the mean annual rainfall is "insufficient to produce percolation through the soil profile". Seleniferous soils may thus "be expected to occur in arid or semi-arid regions, where the soil is derived from selenium-bearing strata". Further, "the distribution of selenium in the soil is not uniform, either in the surface soil or in the soil profile", and selenium "tends to become concentrated in the profile either within or close

*Most of the information contained in this article was taken from a paper entitled "Plants made Poisonous by Selenium absorbed from the Soil", by S. F. Trelease and A. L. Martin, Columbia University, which appeared in *The Botanical Review*, for 1936, Vol. II, pp. 373-396.

to a zone of sulphate accumulation". Thus, amounts of selenium around 22 p.p.m. may occur at the 36-inch depth in such a profile, although only one-third of the selenium may be water-soluble.

### Chemical Relationships.

Selenium is a border-line element, exhibiting both metallic and non-metallic properties. It belongs to the oxygen-sulphur-selenium-tellurium group. Its atomic weight is 79.2. While oxygen and sulphur are typical non-metals, tellurium closely resembles zinc, and is a true metal. Selenium thus occupies an intermediate position, and is known both in a metallic and a non-metallic form. It occurs naturally in small quantities, both in the free state and in combination with metals as selenides, corresponding with the metallic sulphides. Frequently selenides occur as isomorphous impurities in sulphide minerals, such as iron pyrites ($FeS_2$) and copper pyrites ($CuFeS_2$). Selenium forms selenious acid ($H_2SeO_3$) when the oxide ($SeO_2$) dissolves in water. It also forms selenic acid ($H_2SeO_4$), analogous with sulphuric acid, when selenious acid is oxidised, for example, with potassium permanganate.

### Sulphur Antagonism.

In water-cultures of wheat, selenium may produce injury when its concentration is only 0.1 p.p.m. of solution. When sulphate is added (192 p.p.m. of sulphur), a concentration of 18 p.p.m. selenium is needed to produce toxic effects. Evidently sulphate inhibits selenium injury, and thus acts antagonistically. Application of gypsum (calcium sulphate) to soil has been found to reduce the absorption of selenium by wheat grown in seleniferous soil.

### Leaching of Selenium from Soil.

Since selenium and sulphur show close similarity in their chemical properties and relationships, it would appear that soluble selenium compounds, such as sodium selenite and sodium selenate, ought not to be fixed in soil by exchange processes, but rather to be prone to rapid removal by leaching under conditions of high rainfall or continued irrigation. The rate of leaching under heavy rainfall should depend on the permeability of the soil, a sandy soil permitting rapid removal. On the other hand, if the soil is calcareous, or has been excessively limed, calcium selenite or calcium selenate might be formed, and these compounds are somewhat less soluble than the corresponding sodium salts*. Hence they might resist downward leaching, and the time required to remove them under appropriate rainfall conditions might be appreciable lengthened. Soluble selenites are stated to be less available to plants and less toxic than soluble selenates, so that the degree of oxidation of the selenium compound is also a factor deciding selenium effects, and this, in turn, may depend on the oxidation-reduction conditions in the soil.

### Limits of Selenium Toxicity.

In general, any soil containing a residue of selenium greater in amount than 0.5 p.p.m. of soil is considered to be potentially dangerous and any plant material containing over 5 p.p.m. of selenium in its tissues may be toxic to animals consuming it. Plant species exhibit marked specificity in the absorption of selenium from the soil. Thus, prairie grasses absorb relatively small amounts of the element, while certain legumes and species of Compositae absorb large quantities. The magnitude of the selenium uptake, however, depends largely on the type of soil, its content of sulphate, &c., so that field data may be very irregular.

### Toxicity of Tellurium and Molybdenum.

Plants growing on Cretaceous shales in north-central U.S.A. have been found to absorb molybdenum in varying amounts. Livestock fed with molybdenum-containing forage develop symptoms similar to selenium poisoning. On the other hand, tellurium has been found only in a few native plants in Wyoming, and none in farm crops. Wheat seedlings grown in soil containing potassium tellurite accumulated large quantities of tellurium, but it is thought that plants containing tellurium are much less toxic than those containing similar amounts of selenium.

F.H.

* The following *solubility data* have been culled from chemical hand-books for the anhydrous salts at 30°C. Sodium selenate, 85 g. per 100 cc.; calcium selenate, 7.5 g. per 100 cc.; sodium sulphate, 47 g. per 100 cc.; calcium sulphate, 0.2 g. per 100 cc. Thus both sodium and calcium selenates are much more soluble than the corresponding sulphates, and calcium selenate, unlike calcium sulphate, is appreciably soluble in water.

## NITRATE AND SOIL TREATMENT.

As a result of measurements made of the nitrate content of soil growing different crops and receiving different methods of tillage, manuring and mulching, Dr. W. A. Albrecht, of the University of Missouri, has been able to demonstrate that the accumulation of nitrate closely follows seasonal conditions. Manuring failed to effect any great change in the level to which soil nitrate fell when it became exhausted by cropping. The most detrimental effect to nitrate accumulation in fallow or uncropped soil was manifested by treatment with a straw mulch. In the case of all the cultural and manurial treatments to which the soil was subjected, the most noticeable feature was the decline of residual nitrate levels with time.—(*Univ. Missouri Res. Bul.* 250, pp. 27.)

## SUGAR NOTES.

*Compiled by the College Department of Sugar Technology.*

**From Evolution to Revolution in Sugar Growing and Manufacturing.**—*By H. A. Cook.*

In many respects the Hawaiian sugar industry is experiencing rapid and radical changes. These changes the author calls "revolutionary" and shows that they demand pronounced readjustments of previous concepts of agricultural practice, as well as of milling practice, and of all previous ideas of control in both branches.

The first step in this revolution began with the advent of machine loading of cane by the grab method, which coincided with the introduction of new varieties of cane which gave juices difficult to clarify. This latter circumstance, together with the fact that the grab type of loaders brought to the mill larger quantities of soil, created further difficulties in milling and clarification.

Then followed the revolutionary Ewa method of harvesting cane without cutting off the tops (hitherto considered an essential step in the cane harvest). This proved to have distinct advantages, although it created further difficulty at the mill, at the settlers, and at the filter station.

Further change followed. Sling loading evolved into grab loading, which sent tops, leaves, mud, rocks and other debris to the factory in unprecedented amounts; the mills were slowed down, settling and filtering became more difficult, and all ideas of milling and settling capacities had to be revised.

The final development was the evolution of the grab harvester. At Ewa it was discovered that cane could be cut and loaded in one operation with the grab loader, and could be broken off at the roots, even though some of the roots came with it. Engineers have for years been wrestling with the idea of a machine to cut cane; and now it is found that no elaborate machine is necessary. The grab loader will tear off the cane at the roots and load it in one operation, and it is found that one machine with five to seven men will cut and load as much cane as formerly required 30 to 50 men.

Naturally, this new method of harvesting does not improve the situation at the mill or in the clarification department. While the field men have now gone a very long way in overcoming a shortage of field labour and reducing harvesting costs, the mill men are wrestling with the trash and soil that come in with the cane in such amounts as completely to swamp the settlers and filters. The grinding rate has had to be reduced and there were long periods when the mill was stopped altogether. The clarification experts were forced to try many expedients: longer contact of lime with the juice and thorough stirring; double liming with double or single heating. Ammo-phos helped in some cases and not in others; sulphitation helped in many cases; mechanical modifications in settlers, such as the centre well, helped to some extent. But of all the expedients so far tried washing the cane has proved the most successful.

The amount of trash and field soil that comes into the mill under some conditions is startling, as illustrated in the following tare test:

| | Lbs. | Per Cent. |
|---|---|---|
| Gross cane weight ... | 7,970 | 100.0 |
| Trash (tops and leaves) .... | 1,530 | 19.2 |
| Soil or dirt .... .... | 1,110 | 13.9 |
| Net cane .... .... | 5,330 | 66.9 |

The tare will be materially less when the field is perfectly dry, the cane well ripened and well burned.

The greatly increased amount of soil in the juice results in large increases in the amount of filter cake to be handled, which increases polarization in cake on account of difficulty in washing; the fuel value of the bagasse is reduced (in one case the bagasse had 22 per cent. of soil), which raises the amount of extra fuel oil required. However, it has been noted that the situation may be brought back to about normal by the installation of a cane washer. In any case the revolution in cane harvesting methods has imposed extra costs on the milling department; how far these extra milling costs counterbalance the saving in field costs will not be definitely known until more experience has been acquired with the new system.—(*Facts about Sugar*, Vol. XXXIII, No. 1, p. 41, 1938.)

* * *

**Pan Boiling Apparatus Historical and Future.** *By E. Szego.*

The author passes in review all the principal forms of vacuum pans that have achieved prominence in the past, and enumerates their advantages and faults; chief among the faults is the more or less unsatisfactory circulation of the massecuite during the boiling. The vertical tube (calandria type) is in general superior to the coil type, but the major fault of the calandria system is the necessary presence of narrow tubes and a central well which does not function with all the efficiency that might be desired.

As an approach to the ideal vacuum pan of the future the author puts emphasis on the Graentzdorffer system, which consists of concentric rings and is said to suppress all the inconveniences of the older types; in the Graentzdorffer type the central well is present as usual to provide circulation. The new type of calandria, if it can be called such, is dimensioned to have a cross sectional area for upward movement of the massecuite equal to 2.2 times the cross sectional area for downward movement. The special advantage claimed for this type is that the space for motion of the massecuite is large in proportion to the frictional surfaces, hence circulation is less retarded than in tube calandrias. —(*Facts about Sugar*, Vol. XXXIII, No. 1, p. 42, 1938.)

## CHEMICAL NOTES.

*Compiled by the College Department of Chemistry and Soil Science.*

### Montserrat Earthquakes.

In a recent discourse Sir Gerald P. Lenox-Conyngham described "Montserrat and the West Indian Volcanoes". The island of Montserrat has recently suffered from a series of earthquakes. They began about the beginning of 1934 and continued with varying intensity all through 1934 and 1935. In the autumn of 1935 the inhabitants sent a petition to the Governor praying that steps should be taken to discover, if possible, whether there was danger of an eruption. Their anxiety was due to their recollection of the events of 1902 when eruptions of the Soufrière of St. Vincent and of Mont Pelé of Martinique did terrible damage. Such an eruption in Montserrat would be most dangerous to the town of Plymouth. As a result of the petition, a small expedition consisting of a geologist and a physicist was sent out. Frequent severe shocks were felt up to November, 1935. After that date the activity of the volcano became steadily less. A good measure of success was attained in locating the positions of the foci, and it is now known that they were all situated in a belt about four miles wide which crosses the island from south-west to north-east. The West Indian island arc bears strong resemblance to the East Indian arc that runs eastwards from Java. In 1929-30 Dr. Vening Meinesz of the Dutch Geodetic Commission made a gravity survey of the seas around these islands and found that there is a belt of negative gravity anomaly lying outside the island arc. The circular form of island and mountain arcs is suggestive. It is probable that the form is determined by the intersection of a thrust plane with the sphere. Mr. P. Lake has pointed out that the radius of the arc gives the dip of the fault where the thrust plane cuts the surface. It is believed that gravity determinations combined with the consideration of the curvature of the island chain and of the probable position of the over-thrusting foot of the tectonic arc on which the islands have been built up by volcanic agency will throw light on the structure of the region.—(*Nature*, Vol. 139, No. 3516, p. 449, 1937.)

* * *

### Citrus Manuring. Its Effect on Cropping and on the Composition and Keeping Quality of Oranges*.

The primary object of the work was to determine the interaction of the artificial fertilizers commonly used in citrus orchards, and their influence on the composition, quality and keeping quality of oranges. Preliminary information on the effect on cropping and on general growth was also sought. There were 20 treatments applied and six replications of each on 5-tree plots, and all data were statistically analysed. The fertilizer trials were carried out on an estate of the African Reality Trust. The trees were 8-year-old Washington Navels on rough lemon stock. The soil was a well-drained sandy-clay, well supplied with available potash and phosphate. The author summarizes his most important conclusions as follows:—Applications of ammonium sulphate to soil induced very marked increase in weight of crop and number of fruits. There was no significant difference in crop, however, between applications of 2, 4 and 6 lb. of ammonium sulphate per tree. A leguminous cover crop did not increase the nitrogen content of the soil nor the size of the crop. Applications of superphosphate, potassium sulphate and lime did not affect the size of the crop. The amount of out-season fruit was not affected by any of the treatments. The size of an in-season crop, however, showed a significant negative correlation with the following out-season crop. This can be explained on the basis of amount of nutritional reserves. Although applications of nitrogenous fertilizers caused an increased crop, the increase in tree size did not exceed that of the control, rather the reverse. Fruits from all plots of all treatments were analysed for phosphorus, potassium, calcium, nitrogen, ash, dry weight, sugar, total soluble solids, acid, thickness of rind and wastage due to mould. Correlations and partial regression coefficients were calculated for all factors before final conclusions were drawn. A high phosphorus content, and probably also a high calcium content, were associated with a low acid content. On the other hand, a high potassium content caused a high acid content. A high potassium content caused a thick rind of oranges, whereas a high phosphorus content induced a thin rind. A high calcium content caused an increase in the amount of wastage due to mould during storage. Nitrogen had the reverse effect. None of the factors determined had any effect on sugar content except nitrogen, which increased sugar content with increased nitrogen content and ash, which has a similar effect.

Remarks similar to those for sugar apply to total soluble solids. The juice content of the pulp was not effected directly by any of the factors determined. There was a reciprocal relationship between phosphorus and nitrogen and between calcium and nitrogen. There was also a direct positive relationship between potassium and nitrogen and between potassium and ash. High nitrogen was positively correlated with high organic phosphorus irrespective of the amount of total phosphorus present. High nitrogen is therefore apparently necessary for synthesis of phosphatic organic substances.

* F. G. Anderssen, *J. Pomol.*, Vol. XV, 117-59, 1937.

## TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

| | *Foreign.* | *Preferential.* |
|---|---|---|
| | *s. d.* | *s. d.* |
| 30th December .. | 6 1½ | 9 10½ |
| 6th January .. | 6 2¼ | 9 11¼ |
| 13th January .. | 6 1½ | 9 10½ |
| 20th January .. | 6 0 | 9 7½ |
| 27th January .. | 5 10½ | 9 7½ |
| 3rd February .. | 5 4½ | 9 2¼ |
| 10th February .. | 5 2¼ | 8 10½ |
| (11*th February*, 1937) | 6 0¾ | 9 9 |

In view of heavy Empire arrivals of raw sugars for which there has been a comparatively poor demand the market has been rather dull and inactive. A moderate pressure to sell near at hand raws is also being reflected in the terminal market where values are showing substantial declines.

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

| | *Pence per lb.* |
|---|---|
| 29th December .. .. | .. 6 7-8 |
| 5th January .. .. | .. 6 7-8 |
| 12th January .. .. | .. 7 1-8 |
| 19th January .... .... | .. 7 1-16 |
| 26th January .. .. | .. 7 1-8 |
| 2nd February .. | .. 7 |
| 9th February .. | .. 6 15-16 |
| (11*th February*, 1937) .. | .. 10 1-2 |

The market has generally been inactive and price fluctuations have been narrow. The American consumption for December 1937 at 29,160 tons was the lowest figure recorded for some time. There has also been a large increase in stocks, and in view of the existing statistical position and uncertainty of future action by the International Regulation Committee, buyers and sellers have refrained from operating.

* * *

BANANAS.—Demand has been slow with Jamaicas £1 lower at £16 5*s.* per ton delivered London and £16 nearest Station Provinces. Brazilians are £14 a ton delivered London and £15 Provinces.

* * *

LIME PRODUCTS.—*Lime Oil.*—Handpressed continues a slow market with the value unchanged at 32*s.* 6*d.* per lb. The demand for Distilled is disappointing; spot is unchanged at 25*s.*, but business is possible at below this price by negotiation. *Lime Juice.*—There is still no demand for Concentrated, and Raw is slow and unchanged at 1*s.* 9*d.* to 2*s.* 3*d.* according to quality. —(*West India Committee Circular*, 13th January, 1938.)

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

| | *American Mid.* | *Egyptian Giza 7.* | *F.G.F. Sakel.* |
|---|---|---|---|
| 31st December .. | 4.84 | 7.42 | 8.25 |
| 7th January .. | 4.97 | 7.63 | 8.46 |
| 14th January .. | 5.02 | 7.61 | 8.44 |
| 21st January .. | 4.93 | 7.65 | 8.48 |
| 28th January .. | 4.82 | — | — |
| 4th February .. | 4.93 | — | — |
| 11th February .. (12*th February*) | 7.28 | 9.85 | — |

The general tone of the market has shown some improvement mainly in view of reports that the Washington Government is contemplating measures to make considerable reductions in the areas under cotton cultivation. It is expected that American production will be reduced to 10½ million bales as against 19½ million bales. Enquiries for West Indian Sea Island cotton have been limited with prices ranging between 23.5*d.* to 24*d.* per lb.

* * *

COPRA has been much easier with West Indian f.m.s. lower at £13 2*s.* 6*d.* c.i.f. London.—(*West India Committee Circular*, 27th January, 1938.)

* * *

SPICES.—Prices of *Pimento* are unchanged at 64*s.* 6*d.* c.i.f. Havre for orders and 7¾*d.* per lb. spot *ex* store; the demand is slow. The *Ginger* position shows little change with sellers in Jamaica of the No. 3 type quoting 50*s.* c.i.f. with buyers suggesting 47*s.* 6*d.* for January-March shipment. Sellers on the spot ask 57*s.* 6*d.* to 80*s.* for small No. 3 to fine bright bold No. 1. *Nutmegs* are unchanged at 6½*d.* to 7*d.* for sound 110's to 80's at 4¾*d.* per lb. for wormy and broken *ex* store. *Mace* is slow and about unchanged at 2*s.* to 2*s.* 1*d.* for reddish to pale mixed and 2*s.* 4*d.* for fine pale. —(*West India Committee Circular*, 13th January, 1938.)

* * *

COCOA.—During the past month drastic fluctuations in cocoa prices indicated the extreme nervousness prevailing in terminal markets. It is feared that a severe shortage of cocoa is likely to result from the determined efforts of the natives in the Gold Coast to withhold their present crop from the market pending a substantial improvement in prices. On the other hand a severe break in prices may result if the natives decide to sell. Latest quotation for Accra cocoa is 25/3*d.* c.i.f. and locally $5.80 per fanega is paid.—(*By Courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

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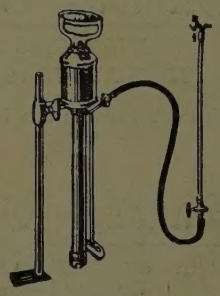

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